FARMERS' MANUAL ON TILAPIA HATCHERY OPERATION IN GHANA

Prepared by:

Seth K. Agyakwah, Ruby Asmah, Emmanuel T.D. Mensah, Catherine Ragasa, Sena Amewu, Nhuong Tran, Mathew Oyih and Peter Ziddah

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FOREWORD

This manual provides a comprehensive step-by-step guide to running a tilapia hatchery operation. It includes advice on site selection, site preparation, hatchery design and construction, farming practices (broodstock management, spawning, sex reversal, hormonal feed preparation and feeding), fingerling harvesting and marketing, biosecurity and fish health management, good farm management practices and recordkeeping – all of which are critical elements of a successful tilapia hatchery operation.

Aquaculture has existed in Ghana since the 1950s, though the sector didn't experience major growth until around 2000, when large-scale commercial production began. Today, it plays a key role in the nation's prosperity, contributing to food security by augmenting domestic fish production and creating jobs.

Even so, challenges that have historically plagued the sector and hindered growth remain pervasive. These include low technical know-how and a lack of quality inputs such as seed and feed. Although knowledge in the sector has increased over the years, small-scale farmers (most of whom are indigenous) continue to struggle with basic farming practices. As a result, they're often faced with poor yields, which can ultimately lead to a farm's collapse.

The Tilapia Seed Project is aimed at accelerating quality Tilapia seed production and dissemination in Ghana. Project stakeholders produced this manual to provide accurate direction to small-scale fish farmers in Ghana. After reviewing its contents, we expect that it will prove instrumental in helping farmers improve production, and will serve as a valuable catalyst for growth in this important sector.

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PREPARATION OF THIS MANUAL

This manual was compiled by researchers (Seth K. Agyakwah, Ruby Asmah, Emmanuel T.D. Mensah, Catherine Ragasa, Sena Amewu, Nhuong Tran) and Fisheries and Aquaculture sector policy regulators (Mathew Oyih, Peter Ziddah), working on the Tilapia Seed Project (*Accelerating aquaculture development in Ghana through sustainable Nile Tilapia seed production and dissemination*), which was funded by the NWO-WOTRO (The Netherlands) and the CGIAR Research Programs on Policies, Institutions and Markets (PIM) and Fish Agri-food Systems (FISH). Some of the information included here was adapted from the following manuals: *Handbook on fish farming* (from the FAO Training Series); a hands-on training handout on small-scale pond and tank fish farming distributed by CSIR-WRI-ARDEC; and selected WorldFish project documents and training manuals. All of the information adapted from these manuals has been tailored to suit the needs of the Ghanaian tilapia fish farmer.

This manual was reviewed by the following aquaculture experts: Dr. Kofi Abban (retired Chief Research Scientist-Fish Geneticist, CSIR-WRI), Mr. Lionel Awity (former Aquaculture Specialist, FAO Africa Regional Office and former Director-Aquaculture and Inland Fisheries, Fisheries Commission, Ghana), Dr. Winnie Sowah (Fish Geneticist, University of Ghana), Mrs. Janet Anchirina (Asuogyaman Zonal Fisheries Director), Mr. Opoku Gyinae (retired Fisheries Officer and private farmer), Ms. Patricia Safo (Director, Crystal Lake Fish Limited), Mr. Godfred Alimo (Manager, S-Hoint Limited), Bright Addo (BritAddo Farms) and Mrs. Florence Danso (Flosell Farms Ltd.).

This manual is a living document that will be updated for the duration of the project. It has not undergone a formal peer-review process through IFPRI or WorldFish. Any opinions stated herein are those of the author(s) and are not necessarily representative of or endorsed by IFPRI, WorldFish, PIM, FISH or CGIAR.

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CHAPTER 1 INTRODUCTION

1.1 Introduction to tilapia culture

Tilapia is a tropical fish species belonging to the family, Cichlidae and is the second most important fish in the global aquaculture industry after carps (SOFIA, 2018). These fish grow quickly and can survive relatively harsh conditions, especially the species, *Oreochromis*. Tilapias are a good source of protein, vitamins and minerals, including significant amounts omega-3 fatty acids.

1.2. Basic biology of tilapia

The general name of this fish group is tilapia but the group consists of three important genera: Oreochromis, Sarotherodon and Tilapia. The distinguishing feature of the 3 is their reproductive behavior. All tilapias are nest builders; fertilized eggs are guarded in the nest by a brood parent. The species, *Oreochromis niloticus* (Plate Error**! Use the Home tab to apply 0 to the text that you want to appear here.**1-1), Nile tilapia is mostly preferred and cultured nationwide in Ghana.

Plate **Error! Use the Home tab to apply 0 to the text that you want to appear here.**1-1:
Orechromis niloticus, Nile tilapia
(Source: Agyakwah et al. 2018)

Advantages of tilapia culture

1. Simple reproduction/breeding processes
2. Rapid growth rate
3. Good tolerance to high stocking densities and intensive rearing conditions
4. Resistance to physical handling
5. High demand in local markets
6. Accepts all kinds of supplementary feeds
7. Can be profitably cultured in seasonal ponds and small ditches/canals close to the homesteads
8. Can tolerate sub-optimal water quality conditions (e.g., dissolved oxygen (DO), temperature, moderate salinity levels)

Disadvantages of tilapia culture

1. Early sexual maturity, which results in excessive spawns/recruitment in ponds
2. Uncontrolled spawning in production ponds often causes overpopulation, resulting in more competition for food, reduced growth, and lower yields of fish big enough to market

1.3 Sex identification

The genital papilla of male is larger and more extended than that of the females and has 2 openings: the urogenital opening, where the milt and urine are excreted; and the anus, for the discharge of fecal waste. The female has a flatter and shorter papilla with 3 openings: the anus, the urethra (for excretion of urine) and the oviduct for the passage of eggs (Plate 1-2: Sex differentiation of Tilapia

(Source: Agyakwah et al., 2018).

Plate 1-2: Sex differentiation of Tilapia
(Source: Agyakwah et al., 2018)

1.4 Why go into tilapia hatchery business?

1. Short turnover (1.5 – 2 months)
2. Small farm area requirements
3. Open to more investment options: high, medium, or small
4. Relatively low risk
5. Operations require less feed
6. Farmers have greater control of prices
7. Wider market opportunities (e.g., market for improved strains, species switch, etc.)
8. Tilapia farming is the fastest growing industry in aquaculture worldwide

CHAPTER 2 PLANNING A TILAPIA HACTHERY—SETUP AND OPERATION

2.1 Factors to consider

Site selection

Selecting a good site for your hatchery is key to the success of your operations. Improper site selection may lead to:

1. Difficulties in holding water in the pond,
2. High seepage,
3. Unfavorable water quality characteristics,
4. Dike erosion,
5. Vulnerability to fish diseases due to poor environmental conditions,
6. Low productivity of the pond, resulting in low yields and economic loss,
7. Inability to drain water completely, and
8. Difficulties in harvesting fry or fingerlings.

Consult with an aquaculture expert or Extension Officer to verify that the proposed site is suitable for production. Consider the factors below.

1. Slope of land and pond design
    a. Sloping land has shallow soil; flat land usually has deep soil
    b. Land with a steeper slope holds fewer and smaller ponds
    c. The pond bottom must have sufficient slope for good drainage
    d. If the slope is too gentle, the pond will not be easily drained
    e. If the slope is too steep, it may be too shallow at one end or too deep at the other end

f. In general, flat land with a gentle slope is most suitable for pond construction
2. The number and sizes of ponds to be constructed
3. Availability of good quality water sources
4. Quantity of water needed for each pond in your farm
5. Climate and rainfall patterns
6. Environment - do not locate your farm in a wetland or flood plain of a river
7. Other users – there should be peace and order among all users of the water source
8. Proximity to customers and farm workers
9. Soil types
   a. Soils are made up of a mixture of living organisms, organic particles (decayed plant and animal materials), mineral particles (such as sand, clay, stones or gravels which have been broken down from larger rocks), water and air.
   b. Soils are generally classified as clay, silt or sand. Clay soils do not allow water to pass through easily. Sandy soils allow water to pass through easily.
   c. Soils that consist of too much sand or clay are not suitable for pond construction.
   d. Topsoil is high in organic material and should not be used to construct pond dikes.
   e. Soils with 20-35% clay are the best for building ponds.
   f. Use soils with a high percentage of clay (30-35% or more) to build the pond dikes and trenches.

Size of operation

In order to estimate the total land area required for pond and hatchery construction, you must first determine the scale of your operation, including the number and sizes of ponds you will be constructing.

Source of water

The most common sources of water used for aquaculture are surface waters (streams, rivers, lakes), groundwater (wells, aquifers) and pipe-borne water (Plate 2-1; Table 2-1). The quantity and quality of water should be adequate to support production since the ponds may require a year-round water supply. Consult your Extension Agent/Officer to check your water quality.

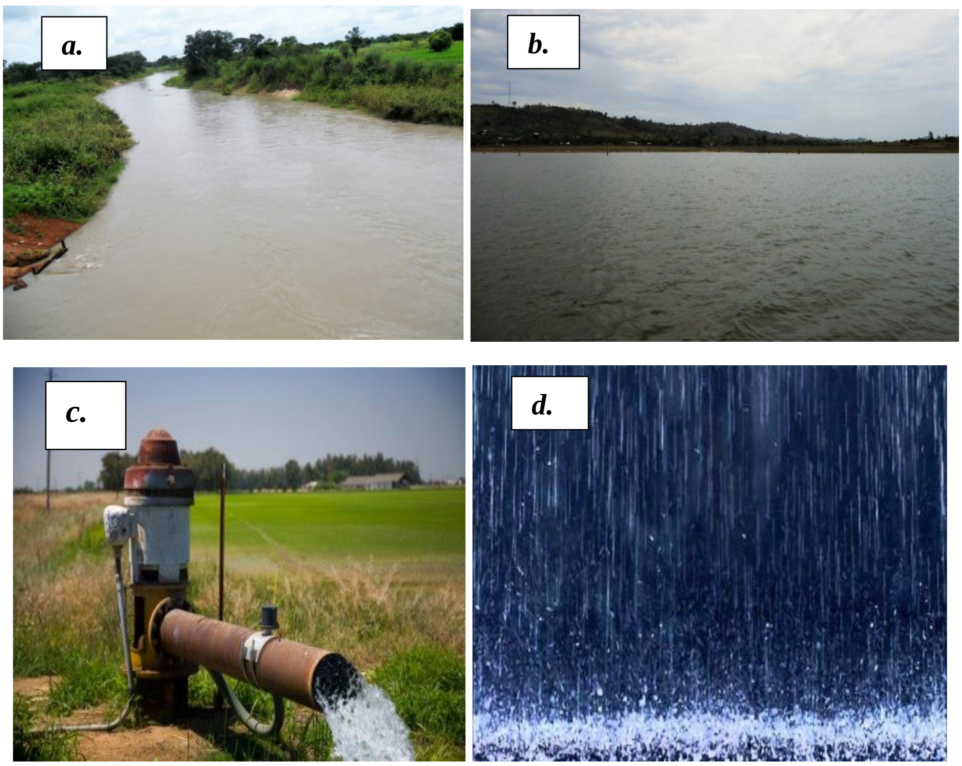

Plate 2-1: Different sources of water for culture: a. river; b. lake; c. underground water; d. rainwater
(Source: Agyakwah et al., 2018)

Table 2-1: Advantages and disadvantages of using these sources of water

Source	Advantages	Disadvantages
Springs	Constant temperature; Few or no known pathogens	One must use pumping machines to pump the water onto the farm – this can increase cost of production.
Wells- pumped or artesian	No predators; Pathogens hardly present	Tends to have high proportions of dissolved gases like carbon dioxide. Low in oxygen.
Rivers, lakes and streams, run-off or rain.	Large volumes of water; Inexpensive	Easily contaminated, predators can easily come for fish. There is also a high level of pollutants and suspended organic matter.
Groundwater	Inexpensive; Few predators	Very difficult to drain, harvesting is difficult, and organic materials can build up very quickly.
Pipe-borne	Very high quality; No predators or pathogens	Chlorine and other added disinfectants can be toxic to fish.

Infrastructure

The selected location should have basic amenities such as access roads and access to electricity, communication facilities and a market.

Market

Marketing is an important component of hatchery operations. It requires knowledge of your customers and their desires. Consider the following when formulating your market strategies:

1. Advertisement of product.
2. Number of clients and their requirement per year
3. The capacity of production per year.
3. Transport equipment and personnel.

Capital

A business plan should be developed before the start of the project detailing the amount of capital to be invested and estimated potential returns or profits.

Permits for aquaculture operations

There are national laws, regulations and policies governing aquaculture production in Ghana (Fisheries Act 625, 2002; Fisheries Regulations, 2010). These permit the use of local species and ban the import of fish for aquaculture.

Before starting your operation, obtain the following permits:

1. Environmental permit from the Environmental Protection Agency (EPA),
2. Water usage rights from the Water Resources Commission (WRC),
3. Aquaculture operational permit from the Fisheries Commission (FC),
4. Operational permit from the Metropolitan, Municipal or District Assembly (depending on pertaining by-laws).

CHAPTER 3 POND DESIGN AND CONSTRUCTION

3.1 Types of ponds/tanks

There are several different types of ponds to consider for your operation.

1. ***Dam/embankment pond:*** These ponds are made by building an embankment, dam or dike across a water course and narrow valley (see barrage pond diagram below). The slope of the land plays a very important role in planning such ponds. A good site is one where a dam can be built across a narrow section of the valley, the sides are gently sloping or steep and there is a gradual decrease in the elevation along its length to permit a large area to be flooded (Figure 3-1).
2. ***Excavated pond:*** These are simple to build and are formed by digging soil from an area to form a pit or hole in the ground. An excavated pond can be supplied by surface runoff, water diverted from a stream or river or water from a well (Figure 3-2).
3. ***Elevated pond:*** This type of pond requires well-constructed impermeable dikes along the sides of the pond. The water supply may need to be pumped depending on the level of the water source. It can be partially drained by gravity (Figure 3-3).
4. ***Elevated/excavated pond:*** The most appropriate type of pond is a combination of excavated/elevated ponds. This is a kind of sunken pond. If the soil has enough clay content, the dike can be built from the soil that is removed during pond excavation; thus, costs are minimized. It can be partially drained by gravity (Figure 3-4).

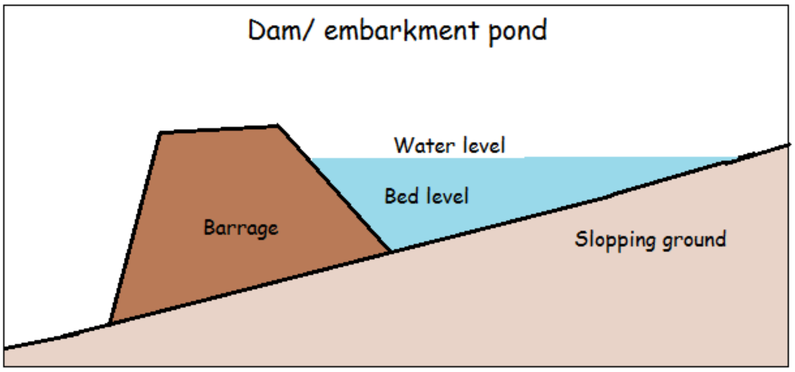

Plate 3-1: Dam/embankment pond
(Source: Ng'ambi et al., undated)

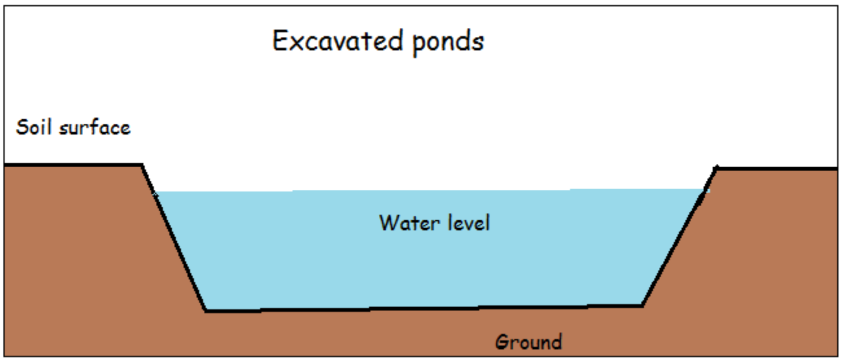

Plate 3-2: Excavated pond
(Source: Ng'ambi et al., undated)

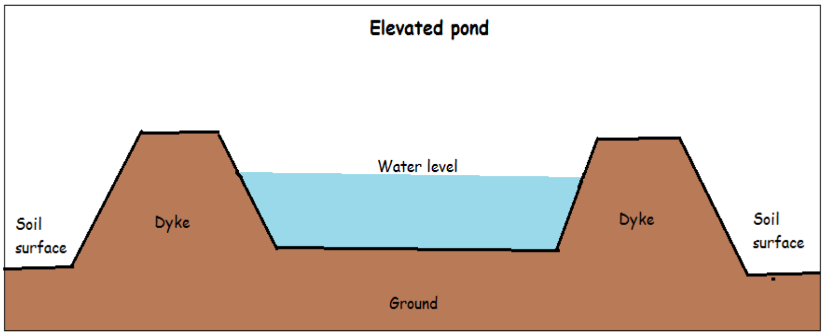

Plate 3-3: Elevated pond
(Source: Ng'ambi et al., undated)

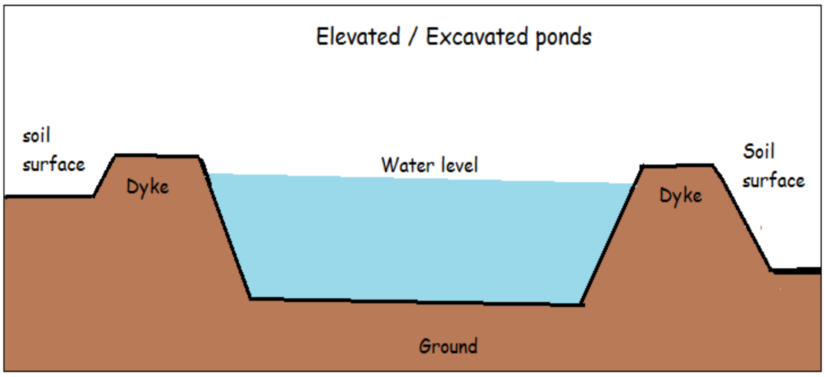

Plate 3-4: Elevated/excavated pond
(Source: Ng'ambi et al., undated)

Ponds are classified according to:

1. Mode of construction (barrage ponds, diversion ponds, sunken ponds),
2. Shape of the pond,
3. Materials used in construction (concrete, earthen, tarpaulin, or polytank),
4. Intended usage (nursery pond, grow-out pond, broodstock/breeding pond, quarantine pond, conditioning pond, sedimentation pond),
5. Drainability (drainable or undrainable).

Classification by mode of construction (Plate 3-5):

- ***Barrage ponds*** are created in the bottom of a valley by building a dam across the lower end of the valley. The barrage pond is drainable through the old riverbed and directly fed from a nearby stream or reservoir. Water enters the pond at a point called the inlet and flows out at a point called the outlet. To protect the dike from floods, a spillway should be built.
- ***The diversion pond*** is fed indirectly by gravity or by pumping through a diversion canal, from a spring, stream, lake or reservoir. The water flow is controlled through a water intake. There is an inlet and an outlet for each pond. It is usually drainable through a drainage canal.
- ***The sunken pond*** is the most common in Ghana. The pond floor is generally below the level of the surrounding land. The pond is directly fed by groundwater, rainfall and/or surface runoff. The sunken pond is undrainable or only partially drainable, since it's built either as a dug-out pond or to make use of an existing hollow or depression in the ground. Sometimes it has additional embankments to increase depth.

Classification by shape: Ponds can also be made in different shapes and sizes. There is no recommended standard pond shape or size. Ponds can be rounded, rectangular or square, large, medium or small. Choose the shape and size that you feel most comfortable managing.

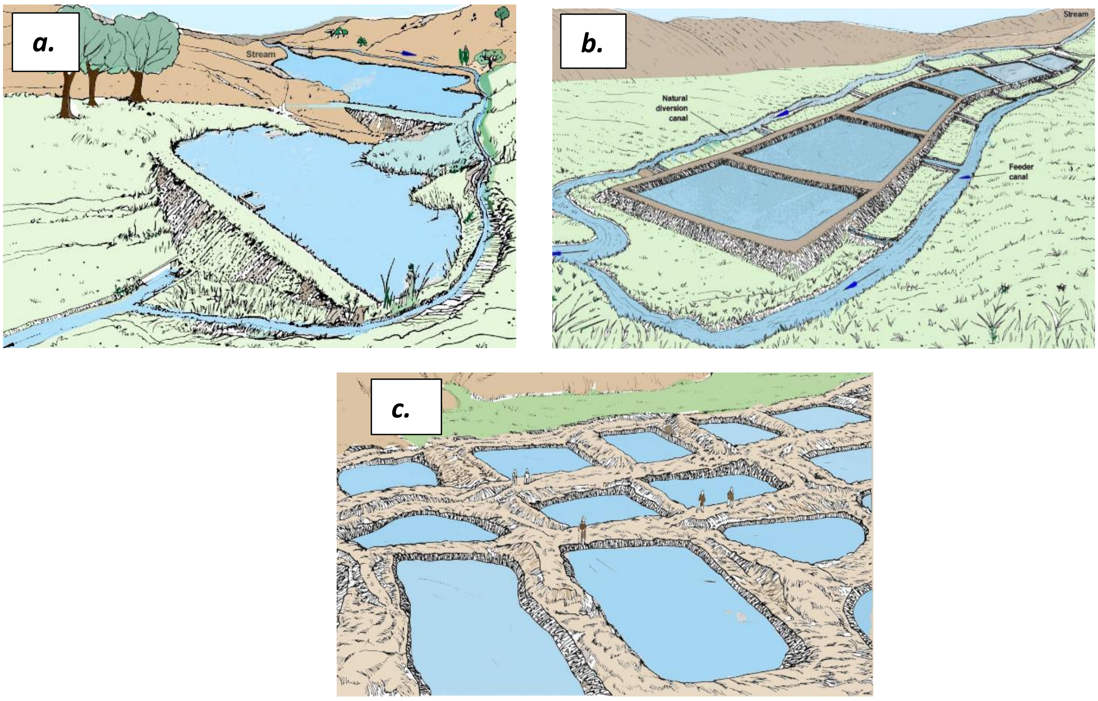

Plate 3-5: Different types of ponds: (a) barrage ponds, (b) diversion ponds, (c) sunken ponds
(Source: FAO Training Series, 2010)

Classification based on materials used in construction: Ponds may be constructed from different materials. Among the most popular materials used are:

1. Earthen material (e.g., soil—clay/silt, etc.),
2. Concrete material (e.g., cement, concrete blocks or cast concrete),
3. Tarpaulin material (used to line a framed or constructed structure such as wooden, plastic or metallic boxes to create a pond).

Classification based on use: Ponds may be used for different purposes. Ponds used in fish farming operations might include nursery ponds for nursing young fish, grow-out ponds for producing table-size or market-size fish, broodstock/breeding ponds for producing fry/eggs, quarantine ponds for temporarily holding fish during biosecurity screening measures, conditioning ponds for stabilizing/preparing fish for transport or sedimentation ponds for stabilizing pond waste water/effluent.

Classification based on whether ponds are drainable or undrainable: Some ponds may be constructed without provisions made to enable easy discharge of wastewater. Such ponds are undrainable or difficult to drain and might require the use of energy to pump out water from the pond. Drainable ponds are recommended because they make pond water management easier.

3.2 Pond Construction

Lining and Pegging: Line and peg to set out the dimensions of your ponds (Figure 3-6) and to indicate the position of pond features (e.g., inlet and outlet points and the dike or pond wall).

Pond size: The size of a prospective fishpond should be based on the purpose of the pond. Smaller ponds are easier to manage. A minimum pond size of 300 m^2 is recommended for small-scale commercial production.

***Pond shape*:** Rectangular ponds are usually the easiest to build and manage. However, ponds must sometimes be built with irregular shapes to fit the topography and shape of the available space.

***Pond depth*:** The pond depth is usually in the range 1–2 m, and is often determined by topography, water source and soil. Ideally, pond water depth should be 0.8 m at the shallow end and increase gradually to 1.2 m at the deep end, with 30–50 cm of freeboard. Ponds entirely dependent on seasonal rains must be deeper (i.e., more than 1.0 m of water depth) in order to hold water longer into the dry season. Maintaining the right depth of water helps to regulate temperature, inhibit growth of underwater plants and maintain dissolved oxygen (DO) levels at the pond bottom.

The slope of the pond bottom: The pond bottom must have sufficient slope for good drainage. In general, slopes with a drop of 2 cm for every 10 m along the pond bottom are appropriate (Figure 3-7). If the slope is too gentle, the pond will not be easily drained. If the slope is too steep, it may be too shallow at one end or too deep at the other end. If your soil has a reasonable percentage of clay (20-30%), you can construct the dikes with 2:1 slope (2 m horizontally for every 1 m vertically). If your soil has a low percentage of clay (20% or less), you should increase the dike slopes to 3:1 to prevent slumping and erosion of the pond banks.

***The digging process**:* The construction approach you choose will depend on the nature of the land.

Digging from the deeper end allows you to:
1. Insert your outlet easily;
2. Prevent flooding during construction;
3. Set out the slope effectively.

The workers should start by digging all around the deeper end and using the excavated soil to form the dike.

Digging from the middle allows you to:
1. Spread the soil material evenly;
2. Make construction less tedious.

The workers should be organized in a row with shovels and digging forks. The central 21 m x 11 m area is dug out first, and the excavated soil is used to build the dike (Figure 3-6). The digging begins at the shallow end of the pond, at the string marking the central area (Figure 3-7; Figure 3-8).

The pond is dug to about 20 cm deep at the shallow end, increasing gradually in depth towards the other end

At the deepest part, the string marking the central area should be about 30 cm deep. As the soil is dug out, it should be placed in the space marked out for the dike, between the 24 m x 14 m rectangle and the 30 m x 20 m rectangle.

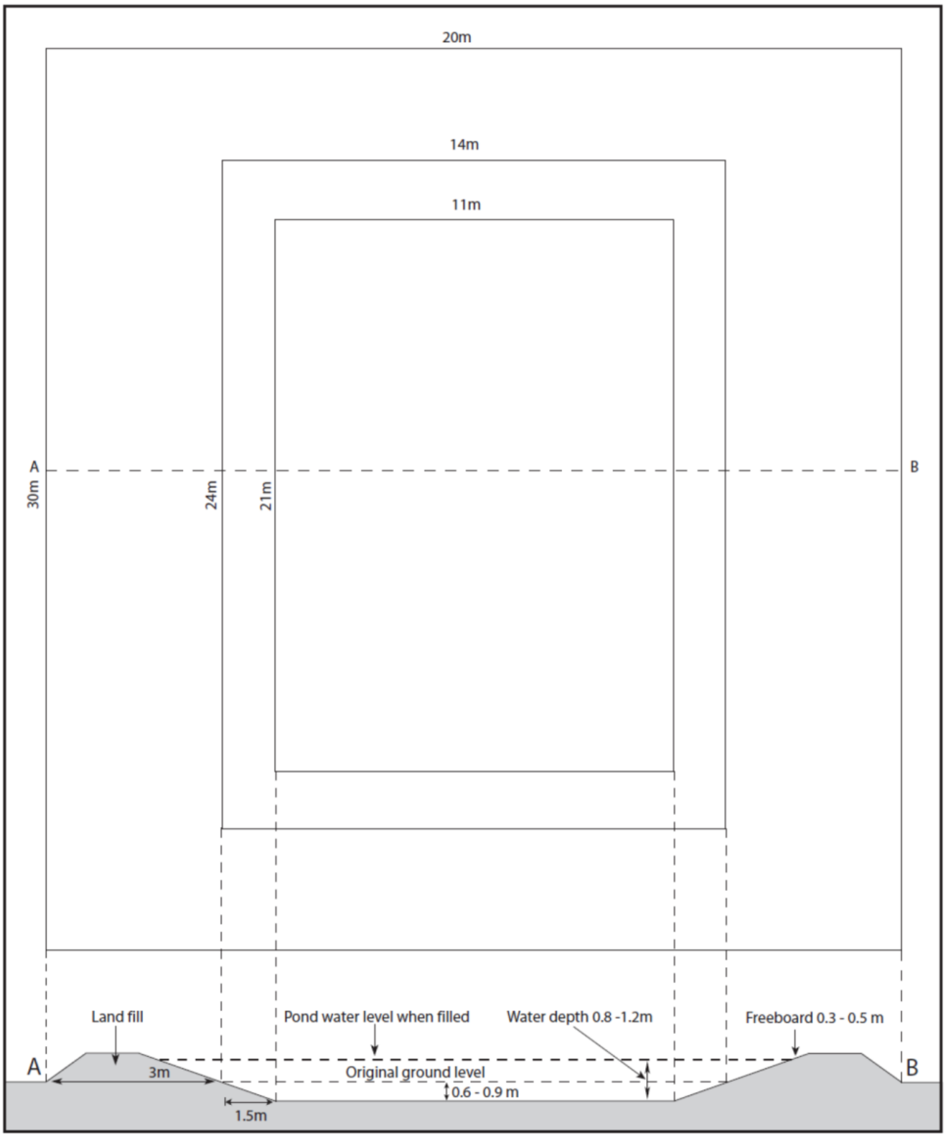

Plate 3-6: Ground plan for a hand-dug pond (top) and cross-section of pond along A-B (bottom)
(Source: Nandlal and Pickering, 2004)

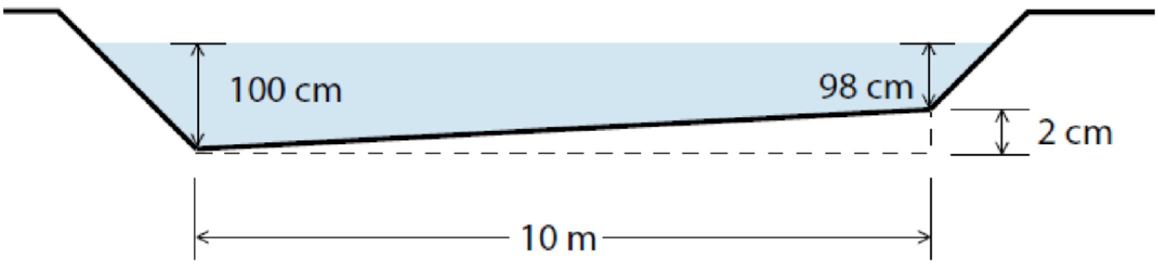

Plate 3-7: The sloping of the pond

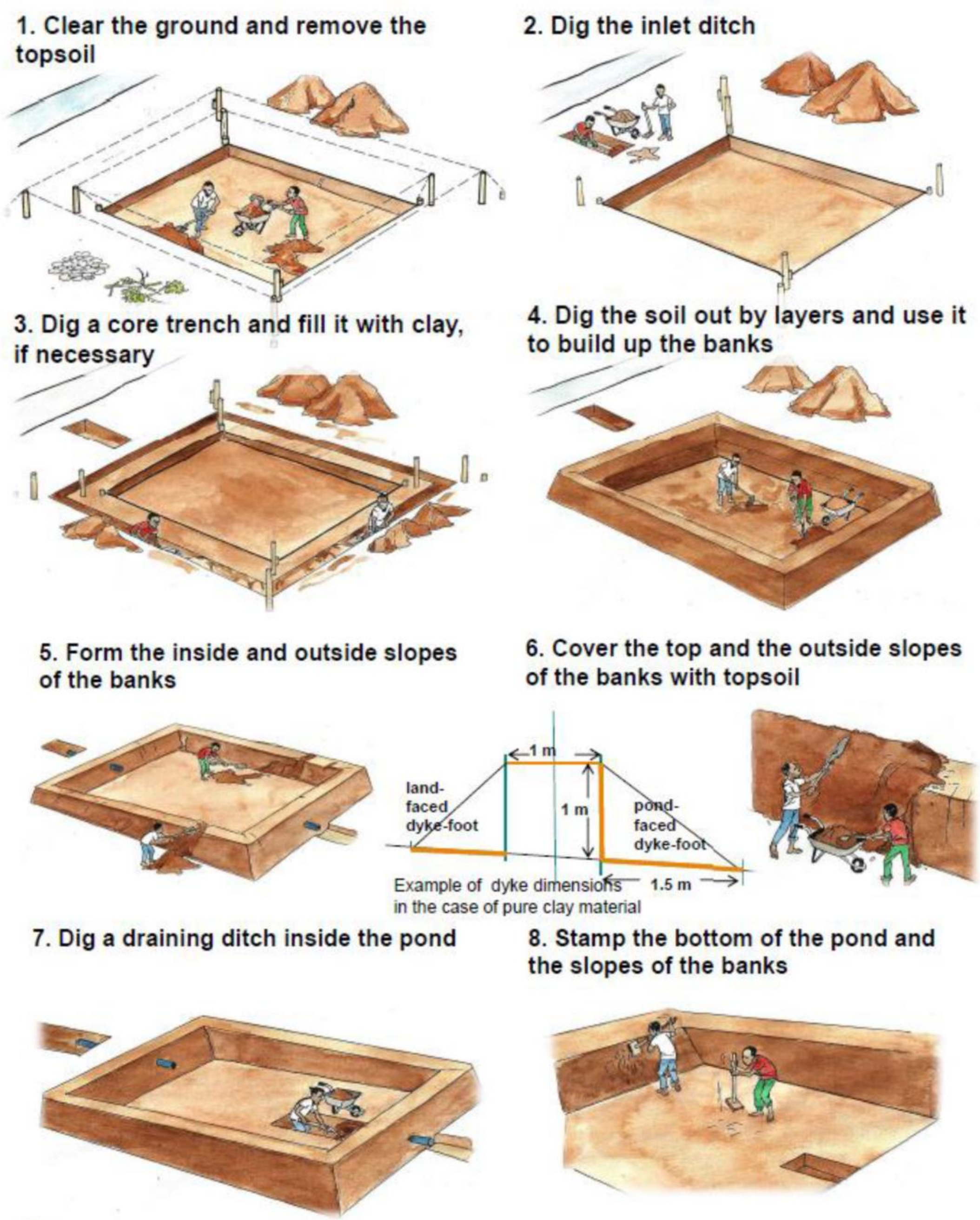

Plate 3-8: Digging your mapped-out pond
(FAO Training Series, 2010)

Installing your pond inlets

1. A water inlet is required to fill the pond with water.
2. Place the inlet at a point nearest to the water source (Figure 3-9).
3. This will usually be at or near the shallow end of the pond.
4. An inlet pipe should be 25–50 mm (1 – 2 inches) in diameter, and long enough to reach across the dike from one side to the other.
5. Once the position of the inlet is decided, dig a ditch across the dike.
6. This should be dug to a level that allows water to flow from the channel or pipe connecting the water source and the pond.
7. The inlet pipe can be placed in the ditch in the dike, and the dike rebuilt over it.

8. Alternatively, if an open channel is used to allow water into the pond, erosion of dike soil can be prevented by using roofing sheet or hard plastic to line the bottom of the channel.

Installing your pond outlet

1. The water outlet is made at the bottom of the dike at the deepest end of the pond (Figure 10Plate 3-9).
2. The outlet is usually made from High Density Pressure Polyvinyl Pipes (pressure pipes) and should be at least 100mm (3.94 inches) in diameter depending on the size of the pond (Table 3-1).

It is appropriate to dig a ditch through the area demarcated for the outlet before the dike is built. It should reach from the deepest part on the inside of the pond through the dike to a lower level outside of the pond, to allow water to drain from the pond. If the outlet is below ground level on the outside of the pond, it will be necessary to dig a drain to take the water away from the outlet.

Table 3-1: Sizes of outlet pipes for ponds with monks

Pond Size (m^2)	Inside Diameter of Pipe (cm)
<200	Not less than 10
200–400	10–15
400–1000	15–20
1000–2000	20–25
2000–5000	25–30
>5000	40 or more

Source: FAO (2002)

Screening the ponds' inlets and outlets: Screens must be placed on the inlet (Figure 3-9), outlet and overflow pipes to prevent fish from escaping and to stop other fish and unwanted organisms from entering the pond (Figure 3-10).

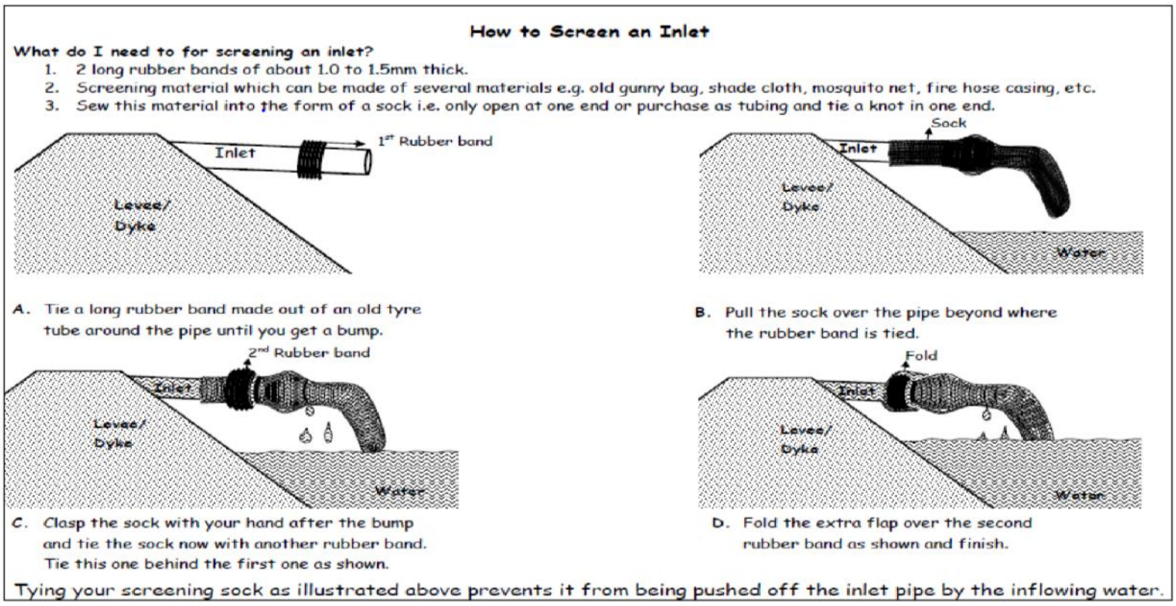

Plate 3-9: How to Screen the Inlet Pipe

(Source: Isyagi et al., 2009)

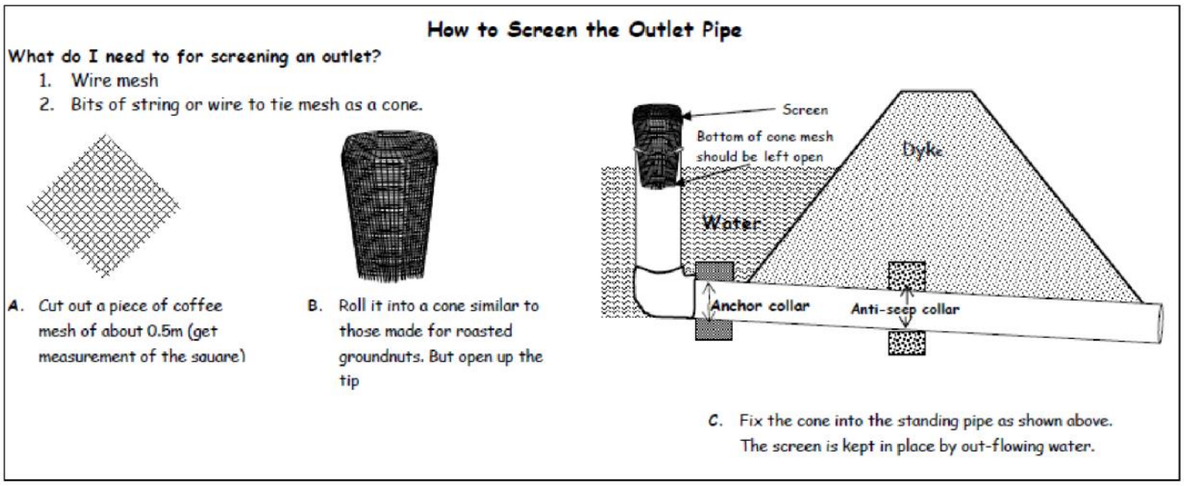

Plate 3-10: How to Screen the Outlet Pipe
(Source: Isyagi et al., 2009)

Bringing water to your pond

Gravity flow: Ensure that the level of the drainage canal is at least 30 cm (11.8 inches) below the level of the pond bottom and at least 1.5 m (59 inches) below the level of the inlet canal. Canal slopes generally range from 0.25 to 1%, but for large ponds the slope should be about 0.5%. Have in place a filtration system, to filter incoming water.

***Pumping*:** Avoid pumping water if there is a cheaper source. Pumping increases the cost of operation. Use the most economical water source.

***Other*:** Plan for a drop of 10 cm from the inlet pipe to the pond water level to prevent fish from swimming out of the pond through the pipe; better still, use a screen to prevent fish from entering the pipe.

Controlling water in your pond

1. If there is too much water in your pond, some may flow over the banks. This may wash the banks away and some of your fish may get out.
2. You can use an overflow to keep the water in your pond from rising over the banks.
3. It is best to place your overflow in the bank at the lower end of your pond right above the outlet so that the water that overflows can run off in the outlet ditch.

CHAPTER 4 TILAPIA HATCHERY OPERATIONS

4.1 Tilapia hatchery

Commercial production of tilapia fingerlings is cumbersome and requires critical water resources, infrastructure, biotechnical knowledge and skill for sustainable production. Until the introduction of the hatchery in the early 2000s, the aquaculture industry in Ghana depended on tilapia fingerlings produced through daily scooping of fry naturally spawned in breeding ponds or hapas.

The general operational process for producing Nile tilapia fingerlings is demonstrated in the chart below (Figure 4–1).

A hatchery is a facility with or without an incubation system to produce fry and fingerlings for grow-out (Figure 4-2). The goal of the hatchery is to produce a consistent quantity and quality of fingerlings for various types of tilapia grow-out operations. There are different systems for production (earthen ponds, concrete tanks, hapas), which require different levels of inputs and management. The system you choose will depend on your area and the number of fingerlings you want to produce.

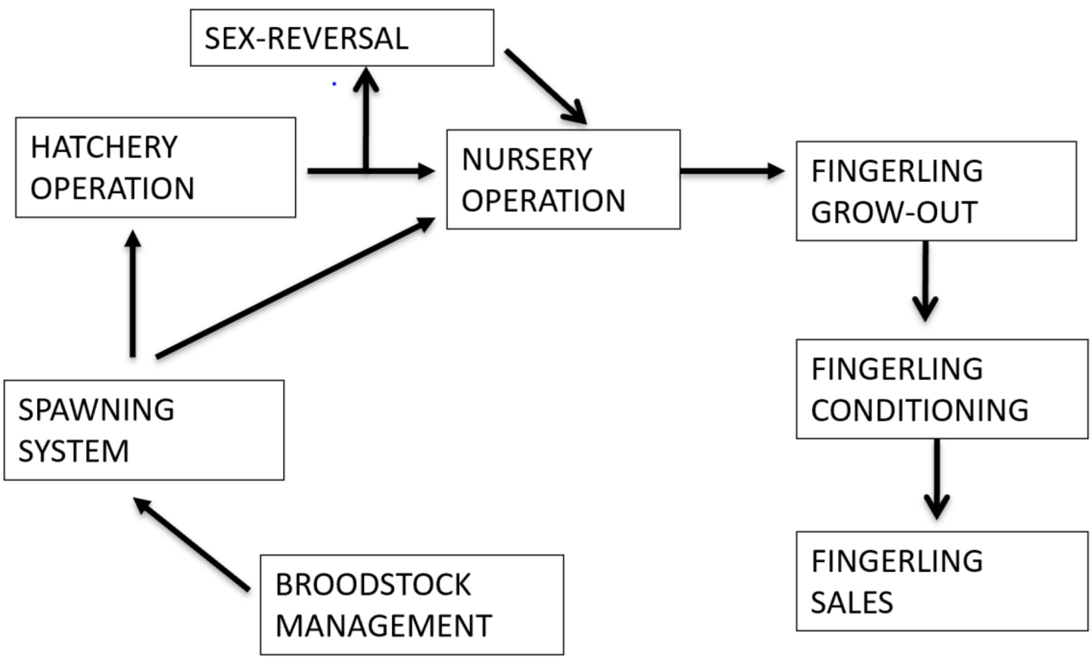

Figure 4-1: Operational processes for Tilapia fingerlings production

4.2 Advantages of a hatchery

1. It can be located almost anywhere that has a suitable supply of water
2. The location can be close to the farmers that will buy your fingerlings
3. It does not always require complex equipment such pumps, aerators, filtration system, electricity, etc.
4. Small size of the hatchery results in low construction cost
5. Relatively easy to manage

4.3 Facilities for a hatchery

1. Ponds or tanks for holding and rearing broodstocks
2. Spawning pond, tanks or hapas
3. Nursery pond, tanks or hapas
4. Conditioning pond/tank
5. Water supply system and storage tank
6. Aeration system
7. Pumps (for recirculatory egg incubation system)
8. Electricity supply and/or generator
9. Basins, buckets, containers
10. Seine nets, scoop nets, grading basket
11. Sensitive scale for weighing fry and fingerlings
12. Accessories for packing of fry and fingerlings

4.4 Types of hatchery pond

1. Nursery pond: for growing/nursing fry to fingerlings
2. Broodstock pond: for rearing/holding the breeders for spawning
3. Sex-reversal pond: for sex-reversal of newly hatched fry
4. Conditioning pond: for holding fingerlings before transport
5. Grow-out pond: for growing fingerlings till harvest (to table-size)
6. Quarantine pond: for introducing new fish to the farm or for treatment purposes
7. Reservoir pond: for storing inlet water before use in the hatchery and nursery

4.5 Fingerling production techniques

Pond method

This is the simplest and most common way to produce tilapia fingerlings. In this method, a pond is used for both spawning and rearing broodstock. The brooders are stocked into ponds and allowed to spawn naturally in controlled conditions (Plate 4-1a).

Advantages

1. Pond management is relatively simple
2. The pond serves as both a spawning and rearing facility; therefore, fingerlings produced are larger than those produced from other methods
3. No supplemental feeding is required if high manuring rates are used

Disadvantages

1. Produces fewer fingerlings than other methods
2. The fingerlings produced are of different sizes, hence grading is required
3. If fry and fingerlings are not regularly harvested, overpopulation could occur leading to stunting and inbreeding

Hapa method

This is a net enclosure sewn using a fine meshed mosquito netting. It is erected at the four top corners with a bamboo mounted in a pond (Plate 4-1b).

Advantages

1. Fry production is high
2. Fry produced are more uniform in size and age
3. Broodstock are easy to handle as they are confined within a relatively small area
4. Fry and broodstock are protected from predators

Disadvantages

1. Require more management than other methods
2. The brood fish in hapas may be easy targets for poachers
3. Hapas may be destroyed or blown away during stormy weather
4. It is essential to feed brooders and fry in a hapa, which raises production cost

Tank method

This method is advantageous when a hatchery is used for producing sex-reversed all-male fingerlings because effluents are easily managed and treated. The should ensure the tank is connected to a steady supply of dissolved oxygen so that good water quality parameters are maintained (Plate 4-1c).

Advantages

1. Fry production per square meter is high
2. Fry are more uniform in size and age
3. Broodstock are easy to handle because they are reared in relatively small area compared to the open pond method
4. Fry and broodstock are well protected from predators

Disadvantages

1. Tanks require more intensive management than other methods
2. The brood fish in tanks may be easy targets for poachers
3. Tanks have high initial capital costs and these may increase overall production costs
4. It is essential to feed brooders and fry in a tank, which raises production costs

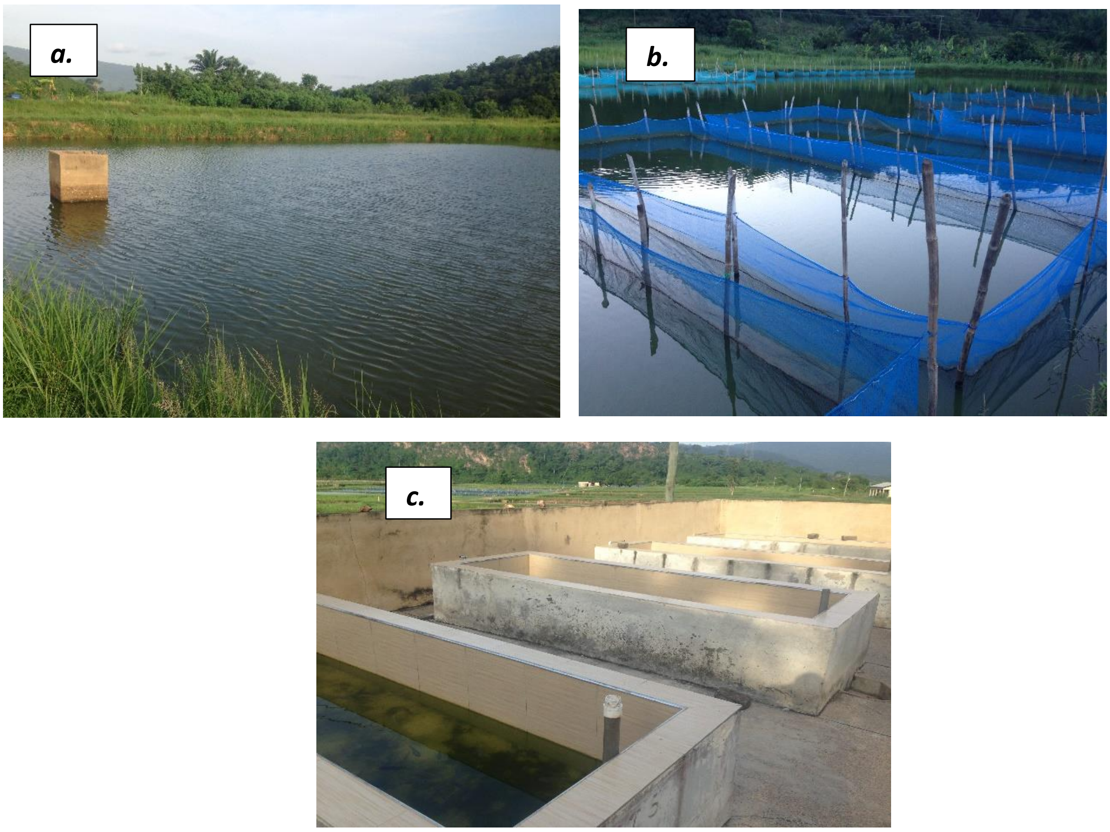

Plate 4-1: Fingerling production methods: (a) Pond method; (b) Hapa method; (c) Tank method

4.6 Artificial incubation of eggs

In order to increase productivity, you can shorten the time between successive spawnings by removing fertilized eggs from the female's mouth. Once the eggs are removed, the female quickly returns to reproductive mode and the cycle of producing eggs continues. Also, quite a number of eggs/ yolk-sac fry that would have been lost to the environment during natural incubation by the female broodstock may be recovered at fry harvest when all eggs/yolk-sac fry are collected from the mouth of the female. The eggs removed from the females are artificially incubated and hatched in jars or trays with clean flowing water under controlled conditions, ensuring high survival rates of eggs and fry and making mass production of uniform seed possible.

Hatching jars should be provided with frequent replacements of water or slow flow-through. Water should also receive aeration to maintain an appropriate dissolved oxygen level (Figure 4-2). The intensity and costs of this operation depend on the level of investment.

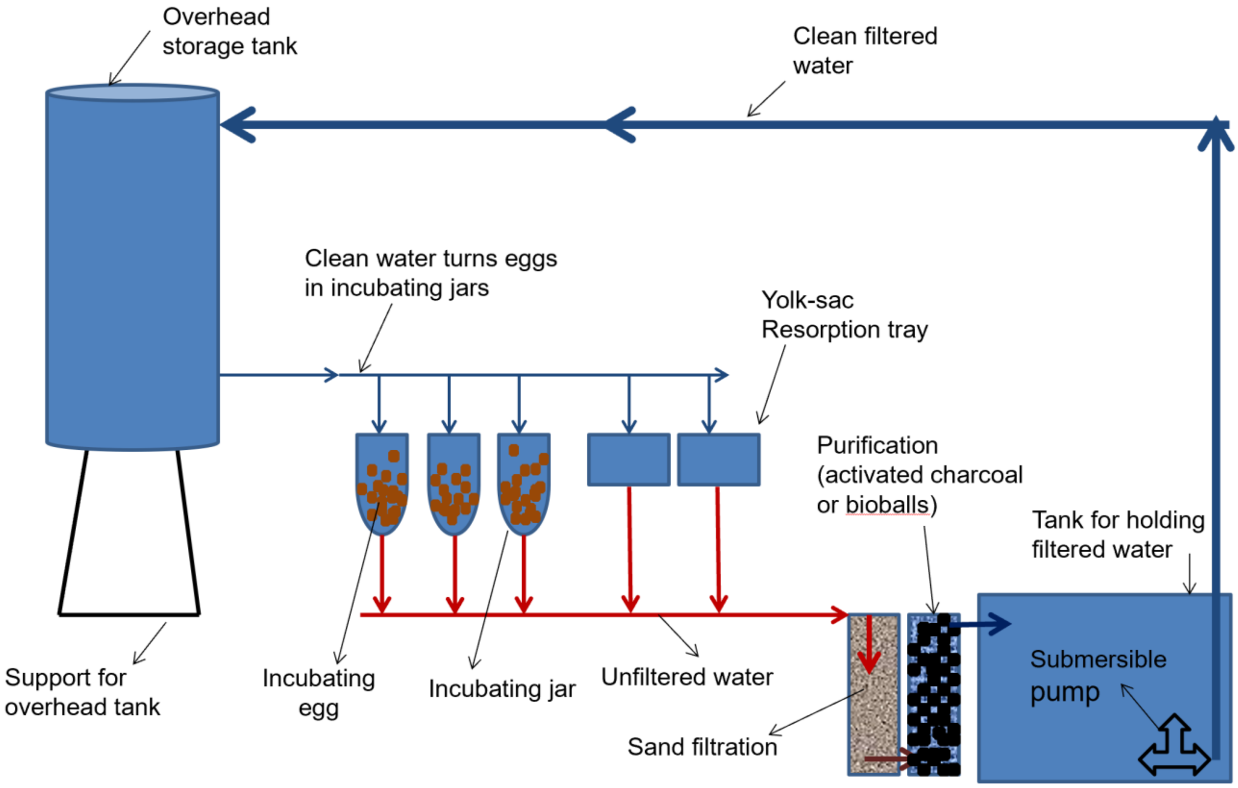

Figure **Error! No text of specified style in document.**: Design of recirculatory incubation system

Advantages

1. High hatching and survival rates
2. Prevents cannibalism and prepares females for further spawning
3. Mass production of uniform seed possible
4. Male tilapia can be mass produced efficiently
5. Various incubation systems are possible, including cheaper ones

Disadvantages

1. Start-up costs may be higher than the natural method
2. May require electricity to run pumps and aerators (may make this method impossible in some rural areas)
3. May require water to run efficiently (water supply may not be readily available in some areas)
4. May need commercially compounded feeds to yield expected returns

4.7 Estimation of tilapia fry production

Several methods can be applied to determine total fry production at harvest. Regardless of the approach you choose, ensure that clean unchlorinated water is used and aerate continuously, if possible. Do not crowd fish in the bowl. Crowding will cause stress and could even kill fish during estimation since frys are very fragile. Fry production estimation should be conducted in the shade where temperatures are cool, or early in the morning or late afternoon.

Individual count technique: This approach involves counting each individual fish harvested or produced (Plate 4-2). The fry to be counted should be placed in one of two bowls filled with clean unchlorinated water. With the aid of a small hand sieve or net, or plastic spoon, pick and count fry one by one as they are passed from one container to another. This technique is precise and useful but also laborious, as you'll be counting several hundreds or even thousands of fish.

Plate 4-2: Counting of Tilapia fry

Plate 4-3: Estimating fry by the gravimetric method

Volumetric method: This approach is based on knowledge of quantity of fry. Small plastic cups or hand/scoop nets can be used to determine the total fry in a system. Fill the full volume of the plastic cup/hand/scoop net with fry to be counted. The total number of fry can be determined as follows:

$$\boldsymbol{Total\ Qty\ of\ fry} = (\boldsymbol{No.\, of\ fry\ counted\ in\ 1\ cup}) \times (\boldsymbol{Total\ No.\, of\ cups})$$

It is better to count the fish in more than 1 cup and use the average number as number of fries per cup. Be careful that the sample is representative of fish from the whole batch by confining and mixing the fish before taking samples. Large and small fry will tend to separate from one another under normal conditions.

Gravimetric technique: Determine the average weight of a number of fry without water. Then the rest of the fry are weighed in groups to estimate their numbers. The fry is weighed in a previously weighed container, such as a plastic strainer, and then counted one by one to estimate their average weight (Plate 4-3).

CHAPTER 5 BROODSTOCK MANAGEMENT

Broodstocks are matured male and female breeders. They can produce fry or fingerlings.

5.1 Source of broodstock and selection

Measures should be taken to ensure that improved broodstock that is made available to the hatcheries or multiplication centers are properly maintained to produce high quality seed for farmers (production system). Most hatcheries operate without the use of improved strains from genetic improvement programs. Bad management of broodstock occurs in most hatcheries, resulting in low and deteriorating performance, which may be due to selection in the wrong direction and inbreeding. These problems arise because most hatcheries lack adequate technical skills, personnel, facilities, space and equipment.

How to maintain the quality of broodstock

1. Prevent any accidental introduction of inferior tilapia types into the breeding system
2. Remove any fish from your system that show slow growth, deformities, signs of disease or parasites, blindness or unusually large and hardened bellies
3. Obtain breeders from known sources
4. Ensure no fish remain in the pond from the previous breeding cycle before starting the next cycle
5. Keep stock lines in secure and separate holding facilities
6. Avoid breeding between closely related fish (inbreeding) by maintaining a large population of breeders
7. Replace broodstock fish every 18–24 months
8. When replacing aging broodstock, choose offspring originating from as many parents as possible for breeding
9. Maintain a systematic record of stocks

5.2 Inbreeding

Inbreeding is the mating together of individuals that are closely related to each other through having one or more ancestors in common. The offspring of such a mating are inbred to a degree dependent on the closeness of the relationship between their parents. The main strategy for the hatchery operator to reduce inbreeding is to maintain a large population of broodstock fish, and ensure that a large proportion of them get a chance to breed and contribute to the next generation.

5.3 Conditioning

Conditioning is a period of resting. Female breeders should be separated from male fish. Both males and females are conditioned for spawning for at least 10–12 days and fed a lesser amount of supplementary feed (2–3% of body weight daily). Fish kept for broodstock should not be used for more than 1.5–2 years. Breed males and females that are similar in size.

5.4 Mouth clipping of male breeders

Male breeders can be aggressive in their mating behavior and can pursue and nip at female fish – especially in confined spaces like hapa nets or tanks – causing them to become exhausted or to suffer scale damage that forms sores, leading to their death. Mouth clipping of male fish with sharp and sterilized scissors to remove the pre-maxilla bone of the upper lip is one method for reducing their ability to inflict damage. Use a disinfectant (e.g., a 10% solution of Betadine) to clean the wound after clipping (Plate 5-1).

Plate 5-1: Mouth clipping of male Nile tilapia

5.5 Broodstock collection, selection and pairing

Broodstock fingerlings of 20–30 grams in weight can be collected from a breeding center (ARDEC) and stocked at the rate of 3–4 fish/m² in small- and medium-sized broodstock rearing ponds. During all phases of the broodstock growing period, the fish should be fed with formulated or commercial feeds containing at least 30% crude protein. Each fish should be fed an amount equal to 3-5% of its body weight.

Males and females are stocked in the same breeding unit. Stocking density varies with pond size. The recommended male to female ratio for breeding or spawning is 1:3. Sexually matured breeders should weigh between 80 to 100 grams each. About 10–15 days after stocking of breeders, schools of tiny fry will be visible in hapas.

5.6 Fry collection and egg incubation

Tilapia show a high degree of parental care to their eggs and fry. Females of the mouth brooding tilapia incubate eggs in their mouths until the young can swim independently (swim-ups). These free-swimming fry can be collected from the edges of the pond, hapa or tanks at an interval of 7–21 days using scoop nets (Plate 5-2). A specialized sieve is then used to separate the eggs, swim-up fry and the shooters.

For a larger scale hatchery, fertilized eggs or yolk-sac larvae should be collected from the mouths of brooding females once every 5–7 days. During harvesting, fry, eggs or yolk-sac larvae are separated. Eggs are then transferred for artificial incubation in various types of plastic bowls with sufficient water to remain submerged. At the hatchery they are washed with clean tap water, weighed and then placed into incubator jars. Water flow rate is adjusted in such a way that all the eggs are gently churned /agitated. Fry produced is estimated and sent into treatment hapa/tanks. Stock between 1000–1500 fry per square meter (Plate 5-3).

Plate 5-2: Processes involved in fry and egg collection
(Source: Agyakwah *et al.* 2018)

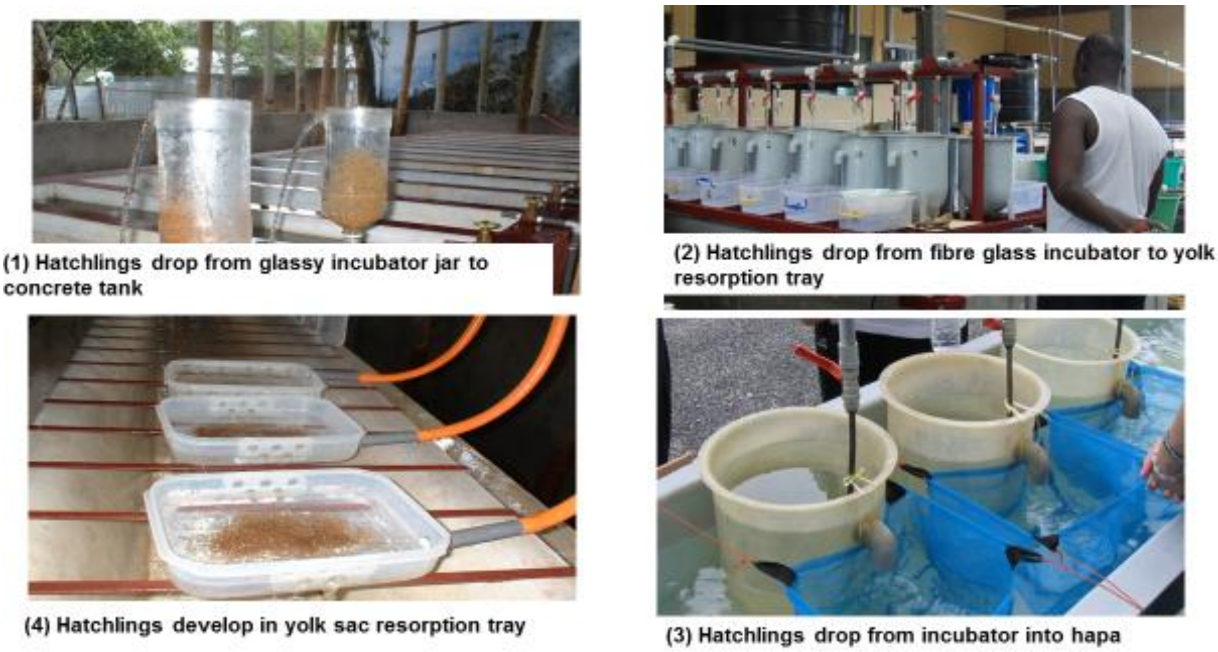

Plate 5-3: Tilapia incubation system
(Source: Agyakwah et al., 2018)

5.7 Sex-reversal technique

Sex reversal is a technique for changing a fish from one sex to another by administering synthetic steroid hormones before and/or during the period of sexual differentiation. In this technique, the first feeding fry are treated with male hormones (i.e., 17α-methyltestosterone), which develops testes and male sexual characteristics at maturity as in tilapia or treatment with female hormones (17α-oestradiol) produces individuals with ovaries and female characteristics in fish as in salmonids and cyprinids.

Advantages
1. Technique is simple and economical
2. No complex facilities or equipment needed
3. A technician or an experienced farmer can run monosex seed production hatchery and nursery systems
4. Overall input costs are not very high
5. If precautionary measures take, reliability of 98–100% male seed production is achieved
6. Ensures high production and high net profit

CHAPTER 6 NURSING FRY TO FINGERLINGS

6.1 Hormonal feed preparation
Early nursing of fry can be carried out in hapas, ponds or tanks. Twenty-one to twenty-eight days of treatment is required for sex reversal. Items needed include male hormone (17α-methyltestosterone), ethanol, finely milled feed, tanks, hapas, unchlorinated water reservoir and well-committed labor.

Steps involved in preparation:
1. Prepare 1 kg of finely milled (sieved) high protein diet (40% CP)
2. Weigh 60 mg of MT into beaker or petri dish on sensitive electronic scale
3. Measure up to 1 liter of ethanol (absolute alcohol) with graduated measuring cylinder
4. Thoroughly dissolve (stirring gently) the MT in the measured alcohol
5. Evenly mix the dissolved MT in alcohol with the finely milled (sieved) feed
6. Spread out MT feed on clean drying sheet and air dry for a few hours
7. Properly bag MT feed for later use

Due to lack of very sensitive scales and difficulty in weighing minute quantities of hormone, a stock solution can be prepared and stored in a refrigerator or cool dry place for a few weeks for subsequent use.

1. Take 5 grams of 17α-methyltestosterone and dissolve in 1liter ethyl alcohol (95%).
2. Prepare 1 kg of finely sieved formulated feed in a clean dry mixing bowl.
3. From prepared stock solution (1L), take 12 ml and dilute to 100 ml of ethanol and shake well.
4. Pour the solution gradually onto the feeds and mix for 10 to 15 minutes.
5. Air-dry the hormone treated feed.
6. Excess hormone mixed feeds can be stored in refrigerator for a week.

6.2 Feeding your fry
Apply hormone feed to newly hatched tilapia fry (length < 13 mm) at 10–20% fish biomass (estimated total weight of fish) at 5 rations daily.

Example

To calculate and apply feed for fry biomass (total number of fry x mean weight) of 2kg per day:

20% of biomass = 0.2 x 2kg = 0.4kg (400g). Feeding rate per ration = 400g / 5 = 80g

Therefore, feed fry 80g at 8am, 80g at 10am, 80g at 12noon, 80g at 2pm and 80g at 4pm.

Best practices
1. Use dry scooping material to fetch hormone feed
2. Broadcast appropriate quantity over surface of water
3. Frequently remove dead fry from surface of water with scoop net

4. Ensure that water is always clean and devoid of algae
5. Partially exchange water to refresh water quality and reduce algae and unwanted exogenous particles
6. Using an external source of food for fry will prevent sex inversion or reversal
7. After 28 days, gently harvest fry in early hours with appropriate scoop nets, containers, etc.
8. Grading can be done if there is wide variation in fish sizes

6.3 Nursing fry to fingerlings

Fry smaller than 1 inch make easy prey for carnivorous fish and birds and are less tolerant to poor water quality, which is a common feature of ponds. Factors such as these increase mortality rates, particularly in the first month of growth. Therefore, nursing fish for at least 1 month before stocking them into grow-out ponds can increase survival rates considerably.

Some considerations for nursing fry

1. The system should be well protected from birds and other predatory fish or animals.
2. Ponds should be adequately prepared before stocking (liming, fertilizing, predator-free) (Tables 6-1 to 6-3).
3. The stocking density depends on fry/fingerling weight (e.g., stock about 750 fry per m² of average weight 0.2 g – 750; 450/m² for 0.5 g; 250/m² for an average of 1 g).
4. Feed fry with a complete diet consisting of 35–40% crude protein.
5. Fry nursing period should be at least 1 month.

Table 6-1: Natural and artificial agents for disinfecting ponds

Product	**Doses**
Quicklime Little water in pond Full pond	 500–900 g/m^3 200–250 g/m^3
Rotenone powder: usually 5 % rotenone from *Derris* roots	20 g/m^3
Saponin, pure glycoside from plant	2–5 g/m^3
Derris root: from *Derris* spp., tuba; roots contain rotenone	20-40 g/m^3
Tephrosia leaves: leguminous tree; leaves contain rotenone	500 g/100 m^3
Barringtonia accutangula: powdered seeds	20 g/m^3
Croton tiglium: powdered oilseed cake	5 g/m^3
Milletia pachycarpa: powdered roots	*Milletia pachycarpa*: powdered roots
Walsura piscidia: powdered bark	10 g/m^3
Bassia latifolia: oilcake; mahua (India)	250 g/m^3
Camellia spp.: teaseed cake; 10-13% saponin	50-70 g/m^3

(Source: FAO Training Series, 2010)

Table 6-2: Lime application rates for ponds

SOIL/WATER pH	pH GRADE	QUICK LIME (CaO) (g/m^2)	HYDRATED LIME [$Ca(OH)_2$] (g/m^2)	AGRIC LIME (g/m^2)
4–5	Highly acidic	150	150	200
5–6	Acidic	100	100	150
6–6.5	Low acidity	60	60	100
6.5–7	Neutral	20	20	40
7–9	Basic	-	-	-

Source: Nnaji *et al*., 2013; Sneyers and Ingawa, 2005

Table 6-3: Organic manure application rates in ponds

INPUT	MODE AND RATE OF APPLICATION	
	BASAL BROADCAST/SAC-FILLED (g/m^2)	TOP DRESSING (g/m^2/week)
Chicken manure	50	5
Pig manure	50	5
Cattle manure	100	10

Source: Nnaji *et al*., 2013; Sneyers and Ingawa, 2005

6.4 Sampling of fingerlings

Sampling allows you to check on the health, growth and general well-being of your fish.

1. It is always advisable to sample frequently (i.e., once every 2 weeks)
2. Sample early in the morning before feeding
3. Scoop a sample of the population (minimum 30 pieces), place it on a scale and divide the displayed weight by the total number of fish to get the average weight of the fish
4. The change in weight from the previous sample will tell you how your fish are growing
5. Remember, fish must always be in water to minimize stress during handling
6. Wear gloves to handle fish
7. Isolate fish that show signs of sickness and report immediately to Extension Officer.
8. Do not sample during extreme stress or poor/bad water quality

Plate 6-1: Processes involved in fish sampling
(Source: Agyakwah et al., 2018)

6.5 Grading of fingerlings

Size variability is common among many species of same-age farmed fish. Variability in growth can be a major shortcoming in the long-term viability of a commercial aquaculture facility. Grading optimizes production by reducing cannibalism, decreasing size variability among harvested fish and improving feed conversion efficiency by using appropriately sized food particles based on the size of the fish. To grade fry by size, sieve the fish through a netting, plastic mesh or parallel bars (Plate 6-2). Several sizes of graders will be necessary depending on the size of fish that will be graded.

Advantages

1. Reduces fish losses due to cannibalism
2. Improves supplementary feeding efficiency through adequate food rationing
3. Increases the accuracy of stock estimates for monitoring
4. Reduces the proportion of undesirable or unwanted sizes
5. Increases production, for example by increasing the proportion of faster growing males in tilapia ponds
6. Allows you to avoid harvesting fish too small for marketing or processing
7. Increases profits

Disadvantages

1. Requires labor, time, and equipment
2. High mortalities could occur if care is not taken

Precautions to be taken when grading:

1. Grade early in the morning or late in the evening
2. All necessary equipment and personnel must be present
3. Scoop a little at a time to grade
4. Always keep fish in water
5. Minimize stress from excessive handling
6. Use gloves to handle fish

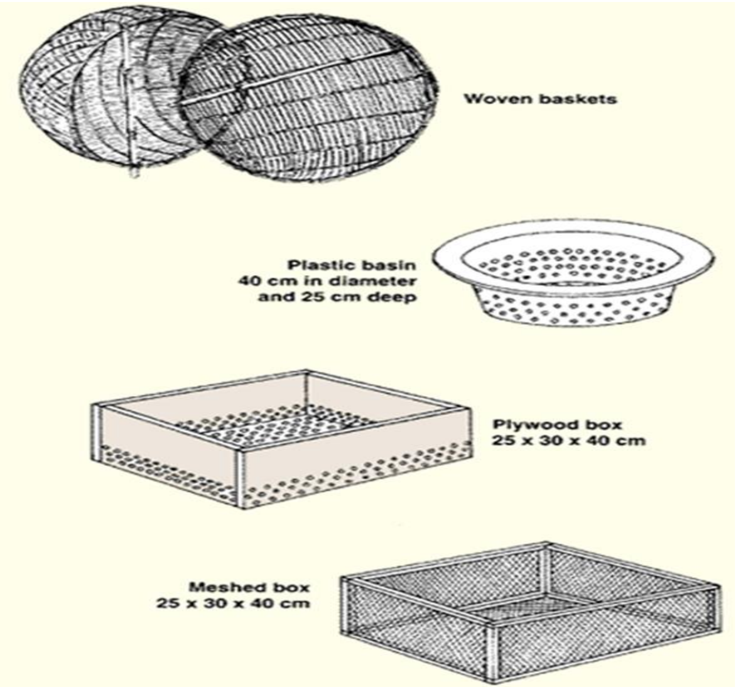

Plate 6-2: Some grading equipment
(Source: FAO, 2006)

CHAPTER 7 HATCHERY WATER QUALITY MANAGEMENT

Fish carry out all bodily functions in water. These functions include breathing, feeding, growth, reproduction and excretion. Water quality affects fish health, growth and performance. It is therefore a critical component of any fish-farming venture.

7.1 How to maintain good water quality

1. Remove any dead fish or eggs from your system as soon as you spot them
2. Look out for signs of bad water in your system
3. When the water is bad, reduce feeding and do not fertilize

7.2 Signs and effects of poor water quality

1. Fish gasp at surface
2. Fish group around fresh incoming water
3. Fish grow slowly
4. Changes in swimming patterns
5. Changes in water color (e.g., too greenish/brownish) or smell (Plate 7-1Plate)
6. Increase in turbidity (water looks muddy, murky)
7. Build-up of nitrogen compounds such as ammonia-nitrogen
8. Phytoplankton blooms

7.3 Causes of bad water quality

1. Use of poor-quality feed
2. Overfeeding
3. Overstocking
4. Decomposition of vegetation
5. Polluted water source

Plate 7-1: Signs of bad water quality

7.4 How to manage water quality

1. Regularly monitor key parameters
2. Aerate when necessary
3. Remove all dead fish as soon as you spot them
4. Regularly change/renew pond water
5. Apply appropriate stocking density

6. Ensure appropriate feeding regime
7. Regularly remove vegetation from ponds

Benefits of good water quality management

1. Good harvest
2. Minimized mortalities
3. Minimized vulnerability to fish diseases
4. Tasty fish – no off-flavor
5. Increased profitability

Effects of poor water quality

1. Poor growth
2. High mortality
3. Poor harvest
4. High financial losses

7.5 Some key water quality parameters and their acceptable ranges

1. pH (6.5–8.5)
2. Dissolved Oxygen (> 3 mg/l)
3. Temperature (25–30 ºC)
4. Ammonia (< 0.03 mg/l)
5. Nitrite (< 0.6 mg/l)
6. Turbidity (< 75 NTU)

CHAPTER 8 CONTROL AND PREVENTION OF DISEASES AND PREDATORS

8.1 Fish diseases

A disease is any abnormality in function, structure and behavior. Diseases can be infectious or non-infectious. Causes of diseases are stress due to environmental factors (bad water quality) or pathogenic infections (micro-organisms: viruses, bacteria, parasites and fungi) (Plate 8-1).

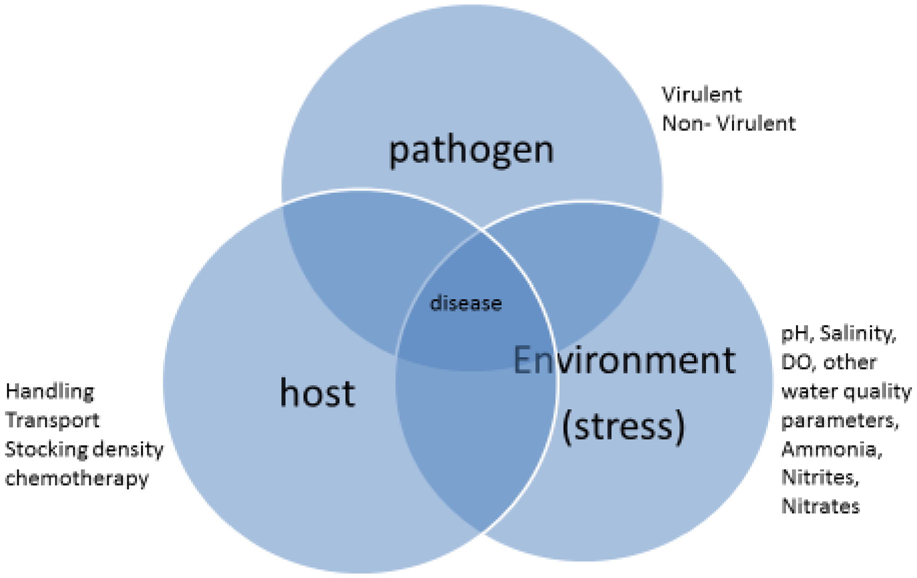

Plate **Error! No text of specified style in document.Error! Use the Home tab to apply 0 to the text that you want to appear here.**: Host, pathogen and environment relationship

8.2 Causes of stress on fish

1. Poor water quality (low dissolved oxygen, improper pH, high temperature)
2. Pollution (chemical treatments, agro-based chemicals, spills)
3. Diet composition
4. Overcrowding
5. Predation and aggression
6. Microorganisms (internal and external parasites, bacteria, viruses and fungi)
7. Procedural stressors (handling, transport, treatments)

8.3 Disease management

Monitor the health of fish by direct observation in the system and during sampling times. Regularly perform visual checks to determine the health situation of your fish. Changes in behavior or physical appearance may indicate disease or unhealthy pond conditions. Individual fish may exhibit increased feed consumption followed by cessation of feeding – or the fish may simply go off feed alone – prior to the appearance of clinical signs of disease.

8.4 Signs and symptoms of disease fish

1. Fish swim near the surface, sink to the bottom, or exhibit loss of balance, flashing or cork-screwing.
2. Behavioral changes often occur when a fish is under stress.
3. Gulping, lethargy and rolling with belly-up could indicate an oxygen deficiency condition, possibly due to blood or gill impairment.
4. Fish mortalities occur persistently, or mortality rates increase day by day.
5. Mortalities that spread from one area to another may suggest the presence of an infectious disease agent. Affected fish should be sampled immediately and kept (isolated) as far away as possible from unaffected animals until the cause of the mortalities can be established.

8.5 Some common fish diseases

Fish diseases are caused mostly by parasites. Maintaining a hygienic environment is the best method for preventing and controlling disease outbreaks. Diseases can occur in a fishpond due to environmental factors that cause stress or as a result of disease-causing pathogens (Plate 8-2). Diseases may be classified as:

1. Bacterial
2. Viral
3. Fungal
4. Protozoan
5. Worms
6. Environmental
7. Nutritional

Follow these steps to treat infected systems:

1. Ponds with infections should be drained and badly infected fish culled.
2. Dry the pond under the sun for about seven days.
3. Dampen the pond bottom.
4. Spread lime (calcium carbonate) evenly across the pond bottom at the rate of 1500 kg/Ha.
5. Wait for 15 days then restock the pond with healthy stock.
6. Hatchery equipment should be disinfected as outlined in Tables 8-1 and 8-2.
7. Quarantine procedures should be instituted to protect resident stock from potential diseases present in introduced stock. This requires the presence of a quarantine area that is isolated from the rest of the farm.

Table 8-1: Disinfection of equipment

Household bleach	• for non-metallic equipment only • make a stock solution at 250 ml/l • use diluted solution = 5 percent stock solution (3 to 4 tablespoons/l)
Iodophores	dosage = 250 ppm AI • Romeiod (0.5 percent AI): 50 ml/l (10 teaspoons/l) • Wescodyne (1.6 percent AI): 50 ml/3 l (10 teaspoons/3 l) • FAM 30 (2.75 percent AI): 50 ml/5 l (10 teaspoons/5 l)
Benzalkonium chlorides	dosage = 200 ppm AI • Roccal (25 percent AI): 4 ml/5 l (4 teaspoons/25 l) • Hyamine 3500 (50 percent AI): 2 ml/5 l (2 teaspoons/25 l)

(Source: FAO Training Series, 2010)

Table 8-2: Disinfection of tanks

Chlorine bleach	for non-metallic tank dosage = 1 000 ppm AI for 20 min or 500 ppm AI for at least 1 h • Chlorine bleach liquid 13 percent AI: 7.5 ml/l (7 500 ppm or about 1 200 ppm AI) for 20 min • Chlorine bleach powder (33 percent AI): 3 ml/l (3 000 ppm or 1 000 ppm AI) for 20 min
Iodophores	dosage = 500 ppm AI for 10 min • FAM 30 2.75 percent AI: 20 ml/l (4 teaspoons/l) • Wescodyne 1.6 percent AI: 30 ml/l (2 tablespoons/l)
Potassium permanganate	dosage: = 1 g/100 l for 15 min

(Source: FAO Training Series, 2010)

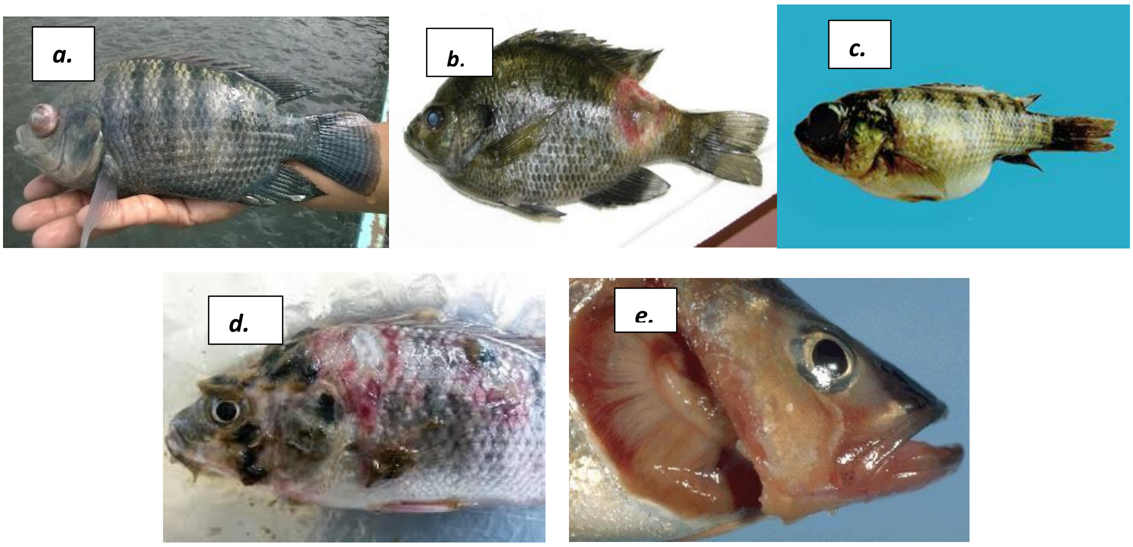

Plate **Error! Use the Home tab to apply 0 to the text that you want to appear here.**: Some diseases of tilapia: (a) pop eye, (b) ulcerations on skin, (c) swollen abdomen, (d) molds and ulceration on skin, (e) gill rot

8.6 Fish predators and their control

Predators are a major source of stress to fish and can also cause significant financial losses. They consume fish and feed and may transmit pathogens to and from systems. Trapping or shooting predatory birds, snakes, frogs, and lizards will help you prevent losses.

8.7 Biosecurity measures

The location of your fish farm is vital to its success. The location may influence other factors like the type of pond you choose to build and its water source. Choose a location suitable for the type of fish farming operation you intend to set up.

Design of farms

1. Know the planned land-use activities of the area
2. Measures to be adopted on farm:

    a. Ensure that all inputs and supplies (e.g., animals, feed, drugs and chemicals, etc.) coming into farm are from a certified source
    b. Incoming water should be safe, adequate and good quality
    c. Vehicles, equipment and visitors must have designated points with clear signage
    d. Regularly disinfect all equipment used to handle fish
    e. Maintain and improve standard of farm sanitation and hygiene (farm, equipment and staff/visitors)
    f. Dead animals and trash fish should be properly disposed of at designated sites
    g. Moribund animals should be kept in a safe location and properly disposed of at designated sites once dead
    h. Reduce stress levels in animals by avoiding overcrowding, overfeeding, underfeeding, over-fertilization of pond, excessive handling, etc.

CHAPTER 9 HARVESTING AND MARKETING YOUR FINGERLINGS

9.1 Harvesting your fingerlings

Your fingerlings can be harvested once the target size is achieved and demand is sufficient. To harvest, drain your pond and collect the fish. This should be done early in the morning before sunrise. Some equipment used to harvest fish include seine nets/drag nets and scoop nets.

Some precautions for harvesting fingerlings include the following:

1. Harvest early in the morning or late in the evening
2. Do not feed fish prior to harvest
3. All equipment and personnel must be present
4. Scoop a little at a time to grade and for estimation
5. Keep fish in water
6. Minimize stress from excessive handling
7. Wear gloves to handle fish

9.2 Conditioning fry/fingerlings

Fry need to be prepared for transport before they are packed. The main problems during fish transportation are shortage of oxygen, high ammonia production from excreta, high temperatures (in hot seasons or areas), and stress due to handling. Conditioning is normally done by the hatchery or nursery and involves the following steps:

1. Prepare holding system (hapa, tanks, cage) before harvesting your fish.
2. Harvest your fingerlings into the holding system.
3. Estimate your fingerlings in your holding system. This can be done during harvesting or after harvesting when the fingerlings are in stable condition.
4. Stock between 100–200 fingerlings of average weight 5 grams per square meter of the holding system.
5. Minimize feeding of fingerlings in the holding system.
6. Observe the condition of fish and maintain good water quality.
7. Condition your fish at least 7 days before transport.
8. Do not feed your fish at least 1 day before transport.

9.3 Fingerlings transportation

Transport of fingerlings involves the movement of fish: within the same farm (on-farm movement), from one farm to another, from one country to another, or from one culture system to another (e.g., from pond to cage).

Certain principles and techniques must be used to ensure high survival rates, a clean environment and healthy fish.

Fish are generally transported in containers such as cans of different sizes, buckets, barrels, plastic bags, Styrofoam boxes, etc. In fact, almost any clean, waterproof container may be used as long as it provides suitable conditions for your fish. Certain containers offer good insulation from heat (e.g., wood or Styrofoam) while others, like metal or plastic, are poor insulators and may have to be wrapped with wet towels or packed with ice to keep temperatures down.

Once fish have been placed in their transport container they should be brought to their destination as quickly and smoothly as possible.

Whenever you're transporting fish, remember the principles below.

1. Care must be taken when transporting fish to your pond.
2. Fish must be well conditioned before transport.
3. Transport active and uniform sizes of fingerlings.
4. Do not transport deformed, inactive or bruised fingerlings.
5. Transport fish in the early morning or late evening (before sunrise or after sunset).
6. Fish must be healthy and transported in clean waters.
7. Fish can be transported in polybags or containers.

8. Use ice to reduce water temperature during transportation.
9. Load your fish in a ratio of 1 kg of fish to 1 kg of water.
10. Allow enough oxygen for aeration.
11. If you carry your fish in poly bags, carry the bags in a box so that they will not break.

9.4 Types of transport systems

Closed transport system

1. Includes polyethylene bags and other sealed transport units
2. Used mainly for the transport of the early fry, but also brood fish
3. Substantially reduces the total volume and weight of transport water
4. Enables public transport to be used for fish-transport purposes
5. Makes it possible to prolong transport time
6. Economically advantageous

Procedure for using a closed transport system (Plate 9-1):

a. Fill the bag with water (5-6 liters, depending on the distance)
b. Stock with fish (200 fingerlings, less for longer distances/rough travel conditions)
c. Insert the oxygen hose to the bottom section
d. Turn on the cylinder valve to dissolve the oxygen into the water
e. Inflate with more oxygen and tie tightly to prevent air and water from escaping
f. Place it in a second plastic bag with water and ice for transportation

Plate**Error! Use the Home tab to apply 0 to the text that you want to appear here.**: Procedure in bagging fingerlings using the closed system

Open transport system

1. Ranges from small transport fish-cans, to containers for fish transport within the territory of a fish farm, up to special fish-transport trucks and tank wagons
2. Requires conditions of constant air or oxygen supply
3. The safety of fish transported in a tank depends on the efficiency of the aeration system, duration of the transport, water temperature, fish size and fish species
4. Circulation is needed to maintain well-aerated water in all parts of the tank

Procedure for using an open transport system:

a. Fill container with clean water and transfer fish at appropriate rate (i.e., for tilapia fingerlings: 200-230 fish/50-liter container of water; and for adult tilapia: 100-150 fish/50-liter container of water)
b. Cover water top with leaves or net to shade fish from sunlight and heat and to reduce splashing and prevent jumping out
c. Oxygenate the water to supply oxygen
d. Avoid delays as much as possible
e. Allow fish to swim out freely from the container during stocking

9.5 Changing water during transport

1. Done when temperatures are high, for longer distances or when water quality goes bad
2. Fresh (new) water should be clean and free from pollutants/pathogens
3. New water should be of similar/same temperature as the initial water
4. Icing may be important for longer trips
5. Oxygenate the water to supply oxygen for your fish

9.6 Releasing your fish

1. Temperatures of the transport water and receiving water should be identical or similar
2. Plastic bags should be floated on the water surface for 15-30 minutes where the fish are to be released while the water exchange and acclimatization procedure is completed (Plate 9-2)
3. Fish are then allowed to swim out of the bags into their new surroundings
4. Fish transported in containers which cannot be set into the new water may be transferred with a soft net, or dipped out with a scoop or bucket
5. Do not pour fish from any height into their new environment
6. Fish will be weak after transport and can easily be injured by rough handling at this stage – allow them to swim slowly into the water (Plate 9-3)

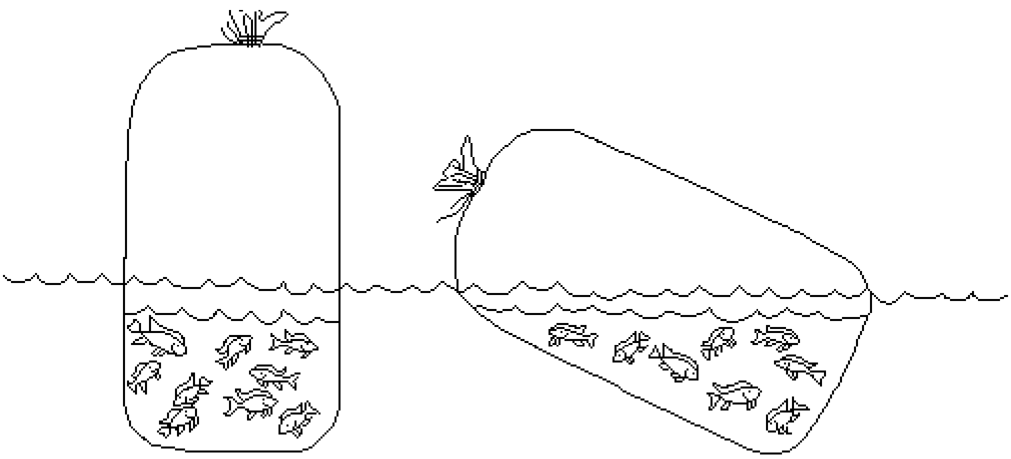

Plate **Error! Use the Home tab to apply 0 to the text that you want to appear here.**: Floating the Bag of Fish before stocking
(Source: Ng'ambi et al., undated)

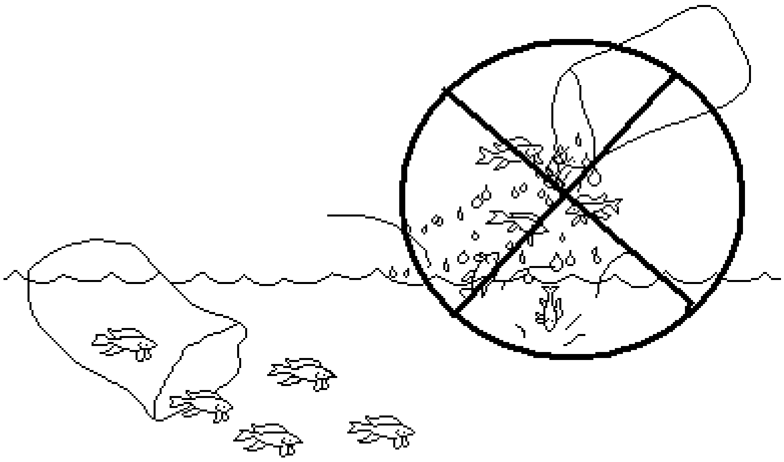

Plate **Error! Use the Home tab to apply 0 to the text that you want to appear here.**: Releasing of fingerling during stocking
(Source: Ng'ambi et al., undated)

CHAPTER 10 BUSINESS MANAGEMENT AND PLANNING

The aim of a commercial hatchery is to produce fingerlings for sale and profits. Therefore, production should be planned to target identified markets.

10.1 Recordkeeping

Records are sets of information that have been systematically and carefully collected and stored for a specific purpose. Recordkeeping is vital to the success of any economic enterprise. Good recordkeeping will help you track farm activities and expenses and assess the managerial level of the farm.

Importance of recordkeeping

1. Provides a basis for farm credit and financing
2. Allows you to control and improve the management and efficiency of the farm
3. Provides information to authorities for policy formulation
4. Allows you to determine the relative profitability of various production techniques and/or systems
5. Provides information for tax purposes
6. Provides data for decision making

10.2 Types of aquaculture records

1. Cost of Production: (1) cost of land, (2) pond construction, (3) inventory of farm assets (4) source and cost of fingerlings, and (5) cost of feeds.
2. Pond utilization table: (1) sampling record sheet, and (2) fertilization and liming.
3. Fish health records: (1) water quality records, (2) harvesting records, (3) feeding records, and (4) records on breeders.
4. Sex-reversal survival records: (1) fingerling sales records, (2) salaries of farm workers, (3) repairs and maintenance, and (4) visitors/Extension Officer.

Table 10-1: Some examples of recordkeeping activity sheet

a. Pond utilization table

Pond number	Date stocked	Pond size	Species stocked	Number of fish stocked	Expected harvest date	Expected harvest (kg)	Actual harvest (kg)

b. Sampling record sheet

Date of sampling	Date of stocking	Pond No.	Number of fish examined	Fish Species	Average fish weight (g)	Remarks

c. Fertilization and liming

Date	Species	Pond number	Pond Size (m^2)	Name of fertilizer/lime		Amount of fertilizer/lime (kg)		Cost of fertilizer/Lime		Remarks
				Fertilizer	Lime	Fertilizer	Lime	Fertilizer	Lime	

d. Fish health records

Date	Pond/tank number	Pond/tank size	Species	Age or size of fish	Usual responses	No. dead	Symptoms	Action taken

e. Water quality records

Pond number............................				Description..................................
Date	Parameter	Reading		Remarks
		Am	Pm	
	PH			
	Temperature			
	DO			
	Turbidity			

f. Harvesting records

Pond number...........		Pond size		Description........		
Date	Number of fish stocked	Number harvested	Species stocked	Average weight (kg)	Expected harvest date	Total weight harvested (Kg)

g. Feeding records

Pond number.........…… Description...						
Pond number	No. of fish stocked	Stocking date	Total weight of fish	Weight of feed fed (kg)		
				AM	PM	Cost of feed

a) Records on breeders

	POND /HAPA NO.)	NUMBER OF FISH		BATCH WEIGHTS (KG)		REMARKS
Date of stocking:		Females	Males	Females	Males	

b) Data sheet template for sex-reversal survival records.

	Sex-reversal hapa	Number of swim-up fry in (A)	No. Of fry	% output = (B/A *100)	Remarks
Date of seed out from the sex-reversal hapa					

a. Data sheet template for fry/fingerling sales records

	Customer details (name, address and tel)	Date of sex-reversal	Number of fry sold (A)	Price of fry (B)	Total revenue =(B x A)	Remarks
Date of seed sale						

(Source: Ng'ambi et al., undated)

10.3 Farm management

In a commercial hatchery setup, the fish farmer must understand that fish are usually reared for economic benefit. The farm manager must make many organizational and operational decisions. Among these are:

1. What species of fish to produce?
2. What quantity of the selected species to produce?
3. What mix of resources and technology to use?
4. When and where to sell or buy?
5. How to finance the operation?

Enterprise Budgets

An enterprise budget is a tool you can use to estimate all expected costs and income for your enterprise over a specified period (e.g., your fingerling production operation during one season or one year) (Table 10-1). Preparing an enterprise budget helps you predict whether the fish farming enterprise will be profitable.

If we assume that a farmer has made all the capital investments required to start the enterprise, normal operating costs incurred and revenues received per unit of time (e.g., one year) can be summarized into an enterprise budget (Table 10-2).

To develop an enterprise budget, the following assumptions must be made:

a. The source of operating funds has been established
b. There is a ready market for the fish
c. The investor is not salaried; she/he relies solely on farm profits
d. The interval of harvest (growing period) and expected yield have been established
e. Mortality or survival rate for the fish stock has been estimated
f. The prevailing bank interest rate is known

Table 10-1: An enterprise budget for a mini hatchery

Item	Unit	Quantity	Unit Cost	Total cost
POND CONSTRUCTION COSTS				
• Clearing • Dike Construction • Pond bottom sloping • water supply PVC pipe • drainage culvert pipe. • overflow PVC. • Backup diesel generator • Construction of caretaker's hut • Construction of storage hut				
Total investment cost				
OPERATIONAL COSTS				
BREEDERS				
• Females • Males **including allowance for mortality*				
FERTILIZERS/LIME				
• Organic (Chicken Manure) • Inorganic • Lime				
FEEDS				
• Breeders • Fingerlings				
SERVICE INPUT				
• Salaries and Wages • Supplies and Materials				

DEPRECIATION				
• Ponds, dikes, etc.@10 years • Equipment @5years • Caretaker's house and storage@5years • Fishing gears, etc. @5years				
SUB-TOTAL				
OTHER EXPENSES				
• Harvesting expenses – 5% of gross sales • Fishing Gears, etc. • Miscellaneous Expenses • Caretaker's/Helper's Incentive • Repair and Maintenance – 3% of gross sales				
Total (K)				
Grand Total (K)				

(Source: Ng'ambi *et al. undated*)

Table 10-2: Cost and Return Analysis of the Tilapia Hatchery (One-year Operation)

ITEM	
Revenue • 5, 000 fingerlings @ 5 ngwee	
Less Expenses • Breeders • Fertilizers • Feeds • Salaries and Wages • Supplies and Materials • Harvesting Expenses • Miscellaneous expenses • Caretaker's Incentive • Repair and Maintenance	
Income before depreciation	
Less: Depreciation	
Net Income	

(Source: Ng'ambi et al., undated)

Economic Analysis

Actual price of pond materials, fingerlings and feed should be used. You can determine fingerling value based on local market price.

$$\text{Net Profit (P)} = (\text{Production x Price}) - \text{Cost (K)}$$

$$\text{Return on Total Investment (\%)} = \frac{\text{Net Profit (P)}}{\text{Cost (K)}} \text{ x } 100$$

10.4 Business planning

Successfully running a tilapia hatchery as a commercial activity (business) requires knowledge and understanding of the aquaculture industry system, marketing system and its relationship to small-scale aquaculture enterprise (Figure 10-1). The most profitable hatchery operators rigorously apply the fundamental principles of enterprise management in the context of inland freshwater aquaculture.

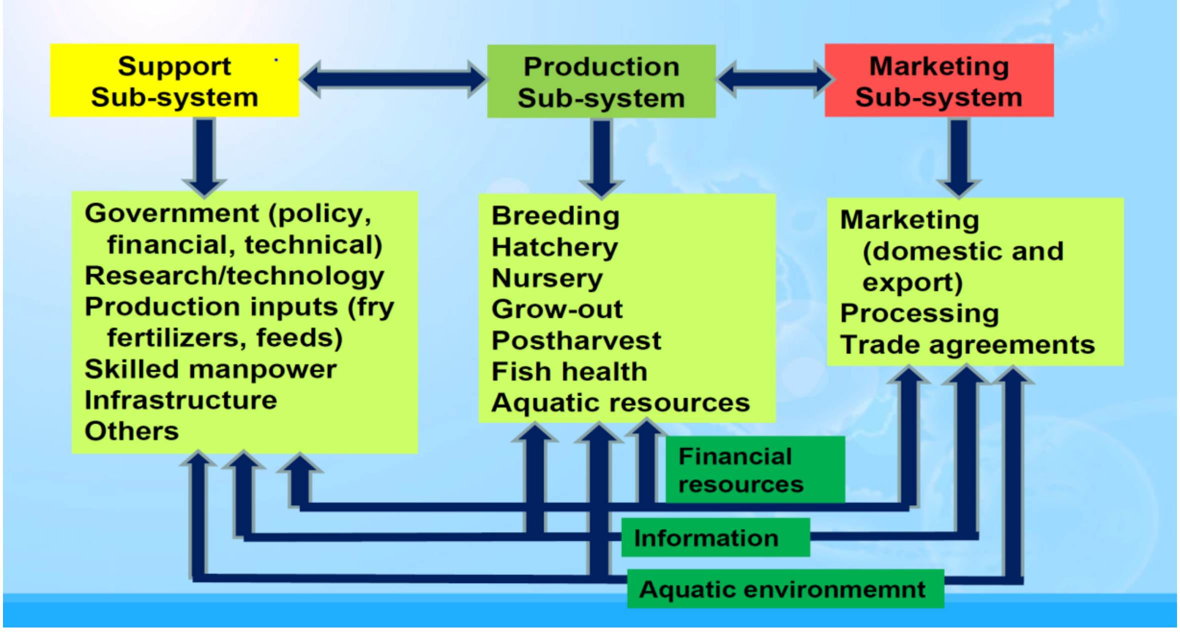

Figure 10-1: Aquaculture industry system showing relationships among the aquatic environment, production, marketing and support systems
(Source: JICA-SEAFDEC 2019 Aquaculture Training Handout)

Factors Affecting Profitability of Hatchery (Aquaculture) Enterprise

1. Increase in production
2. Increase in farm prices
3. Reduction in cost

Enterprise Management Principles/Rules

1. Know your business
2. Understand your customers' requirements and preferences
3. Prepare a realistic plan
4. Build a good team with a good definition of roles
5. Monitor operation status and compare with starting point (baseline)
6. Write down important matters, and save it
7. Ensure customer satisfaction

10.5 Marketing Strategies

When operating a hatchery, you should develop and stick to market strategies that provide maximum benefits or returns to the business. Four (4) key factors (Figure 10-2), also referred to as "the marketing mix," that can be controlled to satisfy customers in target markets are:

1. Product - the good (e.g., table-size fish) or service that you provide
2. Price - how much the consumer pays
3. Place - the location where a product is marketed (e.g., on the farm, TV show, radio, web pages)
4. Promotion - advertising the product to show consumers why they need it and should pay a certain price for it

The four Ps (i.e., Product, Price, Place and Promotion) are constrained by internal and external factors in the overall business environment, and they interact significantly with one another.

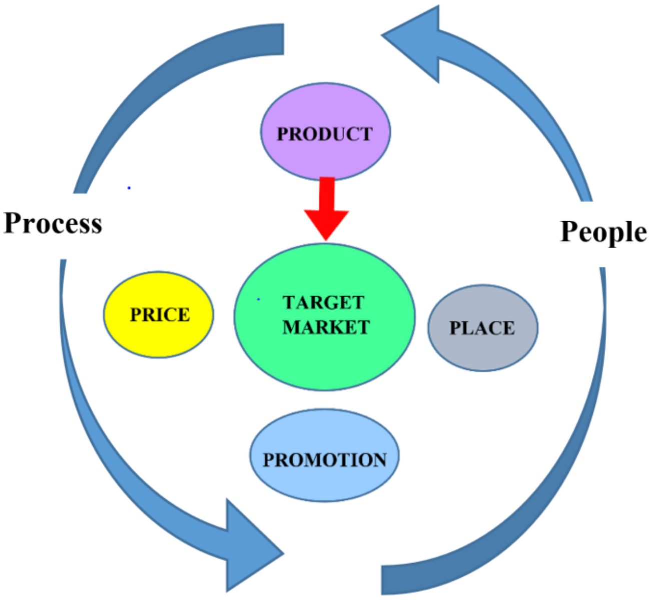

Figure 10-2: The marketing mix with the four Ps (Product, Price, Place and Promotion) and the interactive roles of process and people

1. Identify your key markets
2. You can manipulate any of the four (4) Ps (i.e., Product, Price, Place and Promotion) in an optimal manner to satisfy customers in a target market

Market Study

A resilient Nile tilapia hatchery business operator will desire to conduct market studies from time to time to learn about the preferences of customers (fingerling buyers or grow-out farmers) for product (fingerlings), price and even how to supply the fingerlings. A market study should help you better understand the following:

1. Size, nature and growth of total demand for the fingerlings
2. Description and price of the fish product (fingerlings) at different market levels
3. Overall trend in supply, demand and prices in the fish market
4. Market channels, pricing strategies and promotional tactics
5. Institutional, socio-economic and cultural characteristics of customers

Dealing with Risks and Uncertainties in Aquaculture

In aquaculture business planning, it is important to identify sources of risks and approaches to dealing with them, in order to prevent eventual collapse of the business. Some important sources of risks are:

1. Management and practices
2. Environmental factors
3. Weather and climatic factors
4. Social considerations
5. Markets and prices of inputs and outputs
6. Credit availability and interest rates
7. Government regulations and policies (tax rates, subsidies)

Strategies to Reduce Risks and Uncertainties:

1. Diversification into other aquaculture (e.g., hatchery of other fish species) and agriculture operations (e.g., integration with vegetable, poultry or rice)
2. Aquaculture insurance (though not available in Ghana presently)
3. Improvement in hatchery production technology and practices
4. Financial planning (improving cash flow)
5. Contract pricing (reducing cost)

6. Equipment back-up (pumps, aerators)
7. Management (improved practices)
8. Education/training (improved skills)
9. Adherence to regulatory requirements

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GLOSSARY

Aeration: The mechanical mixing of air and water

Ammonia: A colorless gas with a characteristic pungent smell, which dissolves in water to give a strongly alkaline solution

Broodstock: Matured male and female breeders capable of producing fry

Broodstock/breeding pond: Pond for producing fry/eggs

Canal: An artificial waterway constructed to convey water

Clog: Block or become blocked with an accumulation of thick, wet matter

Conditioning pond: For stabilizing/preparing fish for transport

Culture: Grow or rear

Decomposition: The state or process of rotting; decay.

Disinfect: Clean something, especially with a chemical in order to destroy bacteria

Dissolved oxygen: A measure of how much oxygen is dissolved in the water

Ditch: A narrow channel dug at the side of a road or field, to hold or carry away water.

Dykes: A low wall serving as a boundary or defence.

Embankment: Any raised earthen structure, including dams and dikes, for the purpose of holding back or containing water.
Erratic swimming: Swimming in a way that is not regular, certain, or expected
Excretion: The process of eliminating or expelling waste matter.
Filtration system: The process in which solid particles in a liquid or gaseous fluid are removed using a filter medium that permits the fluid to pass through but retains the solid particles
Fingerling: Related to any fish from advanced fry to about the size of a human finger
Fouling: Make foul or dirty; pollute.
Freeboard: The additional height of a structure (e.g. dike, dam, canal wall) above designated high-water level to prevent overflow.
Fry: A term used to describe a fish at the post-larval stage.
Genitals: The male or female reproductive organs
Grow-out pond: A pond used for producing table-size or market size fish
Gulping: Breathe or swallow with difficulty
Juveniles: Young fish
Hapa: A small, fine-mesh net enclosure set up in a shallow pond to raise fish larvae
Hatchery: A facility used for the artificial and controlled breeding, hatching and rearing of aquatic organisms, on a commercial or experimental basis
Hatchlings: Newly hatched fry
Incubation: The holding of eggs from fertilization to hatching
Infectious pathogen: A biological agent that causes disease or illness to its host
Larvae: An immature form of other animals that undergo some metamorphosis
Loss of appetite: Lack of desire to eat as you normally do
Milt: Sperm-bearing fluid; gonads from male fish
Microorganisms: An organism that can be seen only through a microscope and capable of causing infection
Mold: A fungus that grows in the form of multicellular filaments called hyphae
Moribund: Being in the state of dying
Mortality: The state of being subject to death.
Nursery pond: A pond designated for nursing young fish
Oviduct: A tube serving as the passage for eggs from the ovary
pH: A figure expressing the acidity or alkalinity of a solution
Pond dike: Pond wall/structure intended to hold back water
Polluted: Contaminated with harmful or poisonous substances
Predators: An animal that naturally preys on others.
Production cycle: The period within which all activities related to the conversion of raw materials into finished goods occur.
Quarantine pond: A pond for temporarily holding fish during biosecurity screening measures
Sedimentation pond: A pond for treatment of wastewater/effluent
Sex reversal: Process by which the sexual characteristics of fish are changed, usually through sex hormones.
Slope: A surface of which one end or side is at a higher level than another; a rising or falling surface.
Spawn: To produce or deposit eggs, sperm or young.
Swim-up fry: Referring to fish fry, which have just absorbed almost all of their yolk, becoming buoyant and ready to consume food.
Temperature: The degree or intensity of heat present in a substance or object
Trenches: A long, narrow ditch.
Turbidity: The quality of being cloudy, opaque, or thick with suspended matter.
Urethra: The vessel that transports urine and semen from the bladder to an external opening
Urogenital: An opening for passage of urine and sperm outside the body.
Yolk-sac fry: From the time of hatching until the yolk sac is fully absorbed
Water quality: The chemical, physical and biological characteristics of water